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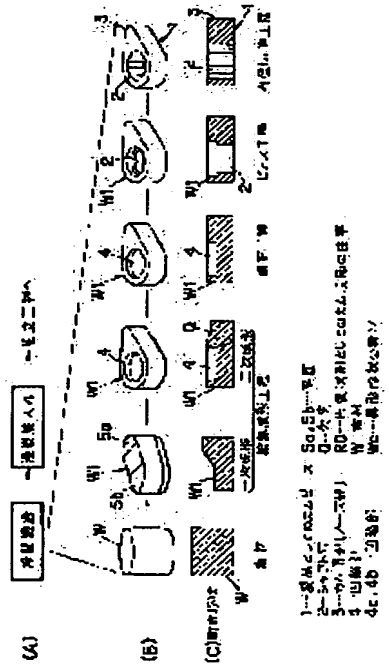
(54) METHOD FOR MANUFACTURING CAM PIECE FOR BUILT-UP CAM SHAFT

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a method for manufacturing a cam piece which is based on cold forging and has excellent accuracy of form.
SOLUTION: This method for manufacturing a cam piece includes the steps of: swaging a material W and forging the material W to form a contour of a cam piece 1, i.e., contour forming step; forming a shaft hole 2 in the center part of the intermediate formed product W1 by blanking, i.e., piercing step; and ironing the inner diameter for finishing the inner peripheral face of the shaft hole 2, i.e., inner diameter ironing step. Shaping in each step is carried out by cold treatment. The shape of the intermediate formed product W1 prepared in the primary forming in the contour forming step is such that, in faces corresponding to one side face of the cam piece 1, a face 5a on a cam top part 3 side is parallel to but is different in level from and has a larger height than a face 5b located opposite to the face 5a and the thickness as the intermediate formed product W1 gradually increases toward the cam top part 3 side.



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CLAIMS

[Claim(s)]
[Claim 1] The contour-forming process which sets a material in the thickness direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, While including the pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, and the bore cover-printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing and performing shaping at each above-mentioned process as a cold treatment As a process configuration by being a configuration with a level difference so that the direction of the part by the side of a cam crowning may become high, though the part by the side of a cam crowning, it, and the part of the opposite side are parallel to the side face of another side among the fields equivalent to one side face of cam piece in the middle of the material in the above-mentioned contour-forming process The manufacture approach of the cam piece for collapsible cam shafts characterized by the thickness dimension as a material serving as a configuration increased gradually toward a cam crowning side.
[Claim 2] The above-mentioned contour-forming process is divided into the primary forming cycle and the secondary-forming process following it at least. The middle Plastic solid after primary shaping By being a configuration with a level difference so that the direction of the part by the side of a cam crowning may become high, though the part by the side of a cam crowning, it, and the part of the opposite side are parallel to the side face of another side among the fields equivalent to one side face of cam piece The manufacture approach of the cam piece for collapsible cam shafts according to claim 1 characterized by the thickness dimension as a middle Plastic solid serving as a configuration increased gradually toward a cam crowning side.
[Claim 3] The contour-forming process which sets a material in the thickness

direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, While including the pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, and the bore cover-printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing and performing shaping at each above-mentioned process as a cold treatment The manufacture approach of the cam piece for collapsible cam shafts characterized by forming beforehand the crowning of the cam piece, and the circular section of equivalent curvature in the material thrown into the above-mentioned contour-forming process at the part which should serve as a cam crowning of cam piece at least.

[Claim 4] The manufacture approach of the cam piece for collapsible cam shafts according to claim 3 characterized by giving the aperture angle equivalent to the crowning of the cam piece beforehand to the part which should become the material thrown into the above-mentioned contour-forming process with the cam crowning of cam piece at least.

[Claim 5] The material thrown into the above-mentioned contour-forming process is the manufacture approach of the cam piece for collapsible cam shafts according to claim 4 characterized by making cam piece and an analog and setting the ratio of the major axis of the material, and a minor axis as the same ratio as cam piece.

[Claim 6] The manufacture approach of the cam piece for collapsible cam shafts according to claim 1 to 5 which makes the multi-process forging press method of construction which comes to contain the above-mentioned contour-forming process, a pierced earring process, and a bore cover-printing process a basic method of construction.

[Claim 7] The above-mentioned material is the manufacture approach of the cam piece for collapsible cam shafts according to claim 1 to 6 characterized by performing carburization processing after the cold treatment which is low-carbon steel or the alloy steel of low carbon, and comes to contain a contour-forming process, a pierced earring process, and a bore cover-printing process.

[Claim 8] The contour-forming process which sets a material in the thickness direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, The pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, The bore cover-printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing is included. The manufacture approach of the cam piece for collapsible cam shafts characterized by performing shaping at each

above-mentioned process with the multistage type forging machine of a horizontal **** type as a cold treatment in the condition of having placed the cam crowning side upside down, at least, respectively.

[Claim 9] The above-mentioned contour-forming process is the manufacture approach of the cam piece for collapsible cam shafts according to claim 8 characterized by including the primary forming cycle and the secondary-forming process following it at least.

[Claim 10] The manufacture approach of the cam piece for collapsible cam shafts according to claim 8 or 9 characterized by performing conveyance of the middle Plastic solid between each process in the condition of similarly having placed the cam crowning side upside down, with shaping at each above-mentioned process.

[Claim 11] It is set up so that the direction of the profile configuration of the middle Plastic solid fabricated at the back process rather than the profile configuration of the middle Plastic solid fabricated at the before process among two adjacent processes may become large. The manufacture approach of the cam piece for collapsible cam shafts according to claim 8 to 10 characterized by pushing in and inserting after carving the cam crowning beforehand and making the cam top equivalent section by the side of a lump agree, in case a middle Plastic solid is pushed in and inserted to a carve lump of the dice of a back process.

[Claim 12] The manufacture approach of the cam piece for collapsible cam shafts according to claim 11 characterized by only the specified quantity making the center-of-gravity location of the lump [carve] by the side of a back process have offset to the upper part side beforehand to the center-of-gravity location of the lump [carve] by the side of a last process as a means to push in and insert a middle Plastic solid after making a cam crowning agree beforehand in the cam top equivalent section of the lump [carve] by the side of a back process.

[Claim 13] The manufacture approach of the cam piece for collapsible cam shafts according to claim 11 characterized by only the specified quantity moving caudad the center-of-gravity location of the middle Plastic solid in the process in which a middle Plastic solid is conveyed at a back process from a last process as a means to push in and insert a middle Plastic solid after making a cam crowning agree beforehand in the cam top equivalent section of the lump [carve] by the side of a back process.

[Claim 14] And a long picture coil strip is supplied to the initial process of a multistage type forging machine. the configuration of cam piece, and abbreviation -- a variant configuration with the cross-section configuration of an analog -- It is the manufacture approach of the cam piece for collapsible cam shafts which was made to

perform with a multistage type forging machine to cutting of the material from a coil strip. The coil strip is set to an uncoiler so that the rewinding starting position of the coil strip which rolled round by ****ing the cam top equivalent section outside may turn down. The manufacture approach of the cam piece for collapsible cam shafts according to claim 8 to 13 characterized by supplying the coil strip to the above-mentioned multistage type forging machine with rewinding.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the manufacture approach of suitable cam piece to unify mutually the hollow-like shaft formed especially separately and the cam piece which is a forging by diameter expansion (expansion) processing of a shaft about the manufacture approach of the cam piece for collapsible cam shafts which will function as a main element of an internal combustion engine's valve gear system, and consider as a collapsible cam shaft.
[0002]
[Description of the Prior Art] The forging besides a sinter is used as cam piece (called a cam lob (cam lobe) or a cam lobe) of a collapsible cam shaft, and it is used, after using the high-carbon steel of S70C and S55C as a material and performing hardening processing after forging, in order to secure surface hardness, especially in being the cam piece of a forging. And as for the cam piece of a forging, it is common to be fabricated by hot forging which was excellent in the moldability as shown in JP,9-276976,A and JP,9-280013,A.
[0003] On the other hand, although a high precision will be required of the dimension

of a shaft, and the inside diameter of cam piece since he is trying for a collapsible cam shaft to guarantee the press fit reinforcement and mutual attachment precision of cam piece and a pipe-like shaft by both press fit cost, the precision prescribe as components is not fully securable in the case of the forging cam piece of the high-carbon steel fabricated with hot forging because of the dimensional change by generating or the heat shrink of the scale at the time of hot forging. Therefore, it is necessary to finish-machine cutting or cold forming etc. which is represented by broaching for inside diameter reservation of cam piece at another process, and the cost rise by the increment in a routing counter and the increment in the management man day of a middle inventory is obliged.

[0004] Moreover, in the case of the forging cam piece of high-carbon steel, in order to secure surface hardness, it is necessary to perform hardening processing but, and It is impossible to make the baking crack at the time of hardening there be nothing as particulars of the quality of the material itself. It burns in order to prevent beforehand the breakage at the time of the press fit assembly which considers the baking crack as a cause, and generating with insufficient insertion pressure, and the sorting process of inspection of the existence of crack generating or a baked crack article becomes indispensable, and the cost rise by the increment in a routing counter becomes much more remarkable with the fall of the yield.

[0005] Then, the manufacture approach of the cam piece based on cold forging replaced with hot forging is proposed as the patent No. 2767323 official report.

[0006] However, if deformation is not made small enough in case it is not only easy to generate defects, such as under-fill, but [since the forging moldability (fluidity of material meat) is low,] plastic deformation is carried out from a material to a required product configuration compared with hot forging, the shaping load over a mold will become large, wear of a mold becomes intense and cold forging tends to cause the early life of a mold.

[0007] Since it becomes the form where only an almost equal amount bulges in the direction of a periphery when a solid cylinder-like material is set on shaft orientations and is especially compressed into them Even if it is comparatively easy to fabricate in a simple circle configuration or the configuration near it a cam piece configuration which compounded the radii section (nose section) which should turn into a circular base circle and a cam crowning more remarkable than this with small radius of curvature -- a breath -- and it is difficult to fabricate so that there may be no generating of under-fill. Therefore, it is necessary to make [many] a processing routing counter in order to carry out slight amount [every] plastic deformation and to

fabricate from a material to a product configuration, and floor to floor time also becomes long and a forging facility will not only become large-sized and expensive, but it tends to cause the fall of productivity.

[0008] This invention is made paying attention to such a technical problem, and though, it offers the approach which enabled it to manufacture the highly precise cam piece which moreover does not have generating, such as under-fill, at a smaller routing counter, on the assumption that cold forging.

[0009]

[Means for Solving the Problem] The contour-forming process which invention according to claim 1 sets a material in the thickness direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, While including the pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, and the bore cover-printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing and performing shaping at each above-mentioned process as a cold treatment As a process configuration by being a configuration with a level difference so that the direction of the part by the side of a cam crowning may become high, though the part by the side of a cam crowning, it, and the part of the opposite side are parallel to the side face of another side among the fields equivalent to one side face of cam piece in the middle of the material in the above-mentioned contour-forming process It is characterized by the thickness dimension as a material serving as a configuration increased gradually toward a cam crowning side.

[0010] Moreover, invention according to claim 2 materialized the publication of claim 1 more, and the above-mentioned contour-forming process is divided into the primary forming cycle and the secondary-forming process following it at least. And the middle Plastic solid after primary shaping is characterized by the thickness dimension as a middle Plastic solid serving as a configuration increased gradually toward a cam crowning side by being a configuration with a level difference so that the direction of the part by the side of a cam crowning may become high, though the part by the side of a cam crowning, it, and the part of the opposite side are parallel to the side face of another side among the fields equivalent to one side face of cam piece.

[0011] in this case -- as a material -- for example, although it is cylindrical (a solid -- cylindrical), when promoting the plastic flow of an ingredient much more and preventing defects, such as under-fill, it is desirable to use the configuration of cam piece and the material of an analog which are a final product.

[0012] Therefore, although the cam piece which has a shaft hole by roughly dividing

and passing through a contour–forming process, a pierced earring process, and a bore cover–printing process will be fabricated in invention given in these claims 1 and 2 As a middle Plastic solid after primary shaping which is a process configuration in the middle of the material in a contour–forming process If it is the configuration which a thick dimension increases gradually toward a cam crowning side, it will come to be promoted in the phase of secondary forming following subsequent forging shaping or subsequent primary shaping, the material flow, i.e., the plastic flow, in the major–axis direction of cam piece. Especially, it comes to act effectively after under–fill generating preventing by the side of a cam crowning.

[0013] The contour–forming process which invention according to claim 3 sets a material in the thickness direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, While including the pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, and the bore cover–printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing and performing shaping at each above–mentioned process as a cold treatment It is characterized by forming beforehand the crowning of the cam piece, and the circular section of equivalent curvature in the part which should serve as a cam crowning of cam piece at least at the material thrown into the above–mentioned contour–forming process.

[0014] Therefore, although the cam piece which has a shaft hole by passing through a contour–forming process, a pierced earring process, and a bore cover–printing process at least like the above will be fabricated in this invention according to claim 3 If the crowning of the cam piece and the circular section of equivalent curvature are beforehand formed in the part which should serve as a cam crowning at least among materials, it will become advantageous, when fabricating the big cam piece of shaping of the profile of the cam piece by cold forging, especially the difference of a major axis and a minor axis.

[0015] Invention according to claim 4 is characterized by giving the aperture angle equivalent to the crowning of the cam piece beforehand to the part which should serve as a cam crowning of cam piece at least at the material thrown into a contour–forming process on the assumption that the publication of claim 3.

[0016] Here, the above–mentioned aperture angle means the include angle which two tangents make, when the tangent cam of the configuration where the base circle of cam piece and the radii section of a cam crowning smaller than this were connected with two tangents which both share is assumed.

[0017] In this case, it is desirable for the material according to claim 5 thrown into a

contour-forming process to make cam piece and an analog like, and to set the ratio of the major axis of that material and a minor axis as the same ratio as cam piece.
[0018] Therefore, in invention given in these claims 4 and 5, the whole part or whole material which is equivalent to a cam crowning at least among materials is exactly formed in the configuration and analog of the cam piece which is a final product beforehand, but becomes easier [shaping of the profile of the cam piece by cold forging].
[0019] In invention given in above-mentioned claims 1-5 here, it is desirable on a productivity drive to make into a basic method of construction the method of construction by the multi-process forging press method of construction, i.e., a multistage type cold-forging machine according to claim 6, which comes to contain a contour-forming process, a pierced earring process, and a bore cover-printing process like in any case.
[0020] Moreover, it is desirable to perform carburization processing like, after the cold treatment which comes to contain a contour-forming process, a pierced earring process, and a bore cover-printing process, using low-carbon steel or the alloy steel of low carbon as a material, after [according to claim 7] being premised on one publication of claims 1-6, after moldability improving between the colds.
[0021] The contour-forming process which invention according to claim 8 sets a material in the thickness direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, The pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, It is characterized by including the bore cover-printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing, and performing shaping at each above-mentioned process with the multistage type forging machine of a horizontal **** type as a cold treatment in the condition of having placed the cam crowning side upside down, at least, respectively.
[0022] In this case, a primary forming cycle and the secondary-forming process following it according to claim 9 may be included at least by the above-mentioned contour-forming process like.
[0023] Moreover, it is more desirable to perform conveyance of the middle Plastic solid between each process with shaping at each process like in the condition according to claim 10 of similarly having placed the cam crowning side upside down.
[0024] therefore, in these invention according to claim 8 to 10 If it inserts for conveying a middle Plastic solid at a back process from a last process, and the metal mold by the side of a process (dice) carving after that, and being crowded (it also

being called in play SHON (impression)) the cam crowning of a middle Plastic solid, and the cam top equivalent section of the lump [carve] which manages shaping of that -- a self ROKETO function or an automatic alignment function -- demonstrating -- an early stage to both -- agreeing -- carving -- the middle Plastic solid within a lump -- being the so-called -- it will roll and a phenomenon will be prevented. Since this is exactly that the location of a middle Plastic solid inclines toward the cam crowning side to the carve lump, and allocation of ingredient (material meat) volume inclines toward the cam crowning side, priority is given to a cam crowning side, ingredient volume is distributed, the ingredient fullness by the side of the cam crowning is promoted, and when preventing the thickness deviation and under-fill by the side of the most important cam crowning on a function, it comes to act very effectively.

[0025] Invention according to claim 11 as a premise of one publication of claims 8-10 It is set up so that the direction of the profile configuration of the middle Plastic solid fabricated at the back process rather than the profile configuration of the middle Plastic solid fabricated at the before process among two adjacent processes may become large. In case a middle Plastic solid is pushed in and inserted to a carve lump of the dice of a back process, it is characterized by pushing in and inserting, after carving the cam crowning beforehand and making the cam top equivalent section by the side of a lump agree.

[0026] More specifically as a means according to claim 12 to push in and insert a middle Plastic solid like after making a cam crowning agree beforehand in the cam top equivalent section of the lump [carve] by the side of a back process Only the specified quantity makes the center-of-gravity location of the lump [carve] by the side of a back process offset to an upper part side beforehand to the center-of-gravity location of the lump [carve] by the side of a last process, or like a publication to claim 13 As a means to push in and insert a middle Plastic solid after making a cam crowning agree beforehand in the cam top equivalent section of the lump [carve] by the side of a back process, only the specified quantity shall move caudad the center-of-gravity location of the middle Plastic solid to a back process in the process in which a middle Plastic solid is conveyed, from a last process.

[0027] Therefore, in case the middle Plastic solid from a last process is inserted in these claims 11-13 to a carve lump of a back process by invention of a publication, it carves with the cam crowning of the middle Plastic solid, and the cam top equivalent section by the side of a lump comes to agree autonomously.

[0028] After being premised on one publication of claims 8-13, invention according to

claim 14 And a long picture coil strip is supplied to the initial process of a multistage type forging machine. the configuration of cam piece, and abbreviation -- a variant configuration with the cross-section configuration of an analog -- The coil strip is set to an uncoiler so that the rewinding starting position of the coil strip which rolled round by carrying out the cam top equivalent section outside may turn down, when a multistage type forging machine performs to cutting of the material from a coil strip. It is characterized by supplying the coil strip to the above-mentioned multistage type forging machine with rewinding.

[0029] Namely, a coil strip is set to an uncoiler so that the rewinding starting position of the coil strip which rolled round by ****ing the cam top equivalent section outside may turn up. When premised on supplying the coil strip to the above-mentioned multistage type forging machine with rewinding, As for the sense of the material cut from the coil strip, a cam crowning side serves as facing up. Since it cannot but become the posture in which the ideal posture in which a cam crowning side which was described previously serves as facing down is reverse, in invention according to claim 14, it is considered beforehand that the rewinding starting position of a coil strip turns down.

[0030] Therefore, not sections but a coil strip is directly supplied to a multistage type forging machine, and in this invention according to claim 14, when premised on carrying out with a multistage type forging machine to the material [itself] cutting, the sense of the material immediately after cutting becomes what was in agreement with the shaping posture in each process, and after that a forging process accelerates, it will become more desirable.

[0031]

[Effect of the Invention] According to invention given in claims 1 and 2, it is premised on the manufacture approach which comes to contain a contour-forming process, a pierced earring process, and a bore cover-printing process at least. Since it is the configuration which a thick dimension increases gradually toward a cam crowning side as a configuration of the middle Plastic solid after primary shaping which is a process configuration in the middle of the material in a contour-forming process, while the material flow of the major-axis direction of cam piece is promoted Since the rate of flow of the material meat by the side of a cam crowning becomes large relatively and the cam crowning side is filled promptly, there is effectiveness which can be fabricated easily without being accompanied by generating of under-fill etc. promptly [crowning / with small radius of curvature / cam]. Moreover, a shaping load required for making a cam crowning side filled with material meat is mitigated, it combines with

reduction of the load of metal mold, and the reinforcement can be attained now.

[0032] By forming beforehand the crowning of the cam piece, and the circular section of equivalent curvature in the part which should serve as a cam crowning of cam piece at least at the material thrown into a contour-forming process according to invention according to claim 3 Shaping of the profile configuration at the time of carrying out cold-forging shaping of the big cam piece of especially the difference of a major axis and a minor axis, i.e., the cam piece with the big amount of cam lifts, becomes easy. There is effectiveness which can be easily fabricated by the routing counter small to a cam crowning especially with small radius of curvature, and also there is an advantage which combines with reduction of the load of metal mold like the above, and can attain the reinforcement.

[0033] By giving the aperture angle equivalent to the crowning of the cam piece beforehand to the part which should become the material thrown into a contour-forming process with the cam crowning of cam piece at least according to invention according to claim 4 In addition to the same effectiveness as invention according to claim 3, shaping of the profile configuration of cam piece becomes still easier, and can attain reduction of the further routing counter, and the reinforcement of metal mold, and also like especially the publication to claim 5 If the material is making cam piece and an analog and is set as the ratio as cam piece with the same ratio of the major axis of the material, and a minor axis, the above-mentioned effectiveness will become more remarkable.

[0034] Since the multi-process forging press method of construction which comes to contain a contour-forming process, a pierced earring process, and a bore cover-printing process also in publication [which / of claims 1-5] is made into the basic method of construction according to invention according to claim 6, while being able to attain the desired end by the necessary minimum routing counter, continuous molding becomes possible, and it becomes possible to aim at cost cut by reduction of a routing counter, and the dissolution of a middle inventory, and improvement in productivity.

[0035] Since the low-carbon steel which was excellent in the moldability between the colds as a material, or the alloy steel of low carbon is used according to invention according to claim 7, it becomes possible to fabricate in a cam piece configuration at a stretch from a material with cold forging, and cold forming of the profile configuration of cam piece and cold forming of a bore configuration can be performed now at the continuous process, and the cost cut by reduction of a routing counter and the dissolution of the inventory between processes is attained.

[0036] Since carburization hardening processing is performed and he is trying to secure required surface hardness after cold-forging processing moreover, compared with the hardening article of high-carbon steel, the hardness distribution differs and, as for the cam piece to which carburization hardening was performed, becomes what has a low internal degree of hardness. And although an impact load will be received in case cam piece inserts a mandrel in the shaft used as the other party and diameter expansion association is carried out, it acts advantageously that the internal hardness of cam piece is low as mentioned above, and it becomes possible for shock resistance to improve as a result and to prevent generating of the crack of the cam piece at the time of diameter expansion.

[0037] According to invention according to claim 10, further according to invention given in claims 8 and 9 by shaping at each above-mentioned process being performed by the multistage type forging machine as a cold treatment in the condition of having placed the cam crowning side upside down, respectively Since conveyance of the middle Plastic solid between each process is also performed in the condition of having placed the cam crowning side upside down, if even insertion makes the middle Plastic solid conveyed from the last process a carve lump of a back process The cam crowning of a middle Plastic solid and the cam top equivalent section of the lump [carve] which manages shaping of that will agree immediately. It carves. Consequently, not to mention the so-called thing [that it rolls and a phenomenon can be prevented] of the middle Plastic solid within a lump Since it is exactly that the location of a middle Plastic solid inclines toward the cam crowning side, and inclines toward a cam crowning side substantially to a carve lump from the stage when ingredient allocation is early The ingredient fullness by the side of a cam crowning is promoted much more, prevents certainly the thickness deviation and under-fill by the side of the most important cam crowning on a function, and can contribute now to the forging progression in quality greatly.

[0038] In case a middle Plastic solid is pushed in and inserted to a carve lump of the dice of a back process according to invention according to claim 11 Make it push in and insert, after carving the cam crowning beforehand and making the cam top equivalent section by the side of a lump agree, and according to invention given in claims 12 and 13 [whether only the specified quantity makes the center-of-gravity location of the lump / carve / by the side of a back process offset to an upper part side beforehand as the concrete means to the center-of-gravity location of the lump / carve / by the side of a last process, and] Or since it is made only for the specified quantity to move caudad the center-of-gravity location of the middle Plastic solid to a

back process in the process in which a middle Plastic solid is conveyed, from a last process It carves with the cam crowning of the middle Plastic solid, the cam top equivalent section by the side of a lump comes to agree autonomously, the ingredient fullness effectiveness by the side of a cam crowning is promoted much more, and there is an advantage which can prevent more certainly the thickness deviation and under-fill by the side of a cam crowning.

[0039] And in charge of supplying a long picture coil strip to a multistage type forging machine directly according to invention according to claim 14 -- the configuration of cam piece, and abbreviation -- a variant configuration with the cross-section configuration of an analog -- Since it considers beforehand that it is in agreement with the posture to which the sense of the material after the cutting made the above-mentioned cam crowning facing down The configuration precision can be further stable, the ingredient fullness by the side of a cam crowning being promoted further, and preventing the thickness deviation and under-fill by the side of a cam crowning, and also reduction of a forging routing counter and reduction of a manufacturing cost can be aimed at compared with the case where sections are used as a material.

[0040]

[Embodiment of the Invention] Drawing 1 -9 show the gestalt of more desirable implementation of the manufacture approach of the cam piece concerning this invention.

[0041] As shown in (A) of drawing 1 , with the gestalt of this operation, it is premised on using low-carbon steel or the alloy steel (for example, SCr420H material whose content of Carbon C is 0.2%) of low carbon as a material W of the cam piece 1 about the collapsible cam shaft which will be assembled by passing like cold forging, carburizing, and an erector. Since the ingredient of low carbon has the good moldability between the colds, it becomes possible [fabricating in a cam piece configuration at a stretch from Material W with cold forging]. Consequently, cold forming for fabricating cold forming and the bore configuration for fabricating the profile configuration of the cam piece 1 can be performed now at the process of continuation so that it may mention later, and the cost cut by reduction of a routing counter and the dissolution of the inventory between processes is attained.

[0042] the process of cold forging is subdivided still as shown in (B) of drawing 1 , and (C) -- having -- **** -- a solid -- with the contour-forming process fabricated in the configuration of the cam piece 1 with the material [being cylindrical (cylindrical)] W The bore cover-printing process which carries out finishing shaping is included in the

variant configuration like for example, a hole spline configuration about the correction process which prepares the thickness dimension of the cam piece 1, the pierced earring process which performs punching processing of the shaft hole 2 formed in the center section of the cam piece 1, and the inner skin of the shaft hole 2. If it is the routing counter of only this, it will become possible to carry out continuous molding of all the processes from a contour-forming process to a bore cover-printing process with a high-speed multi-process forging press machine (multistage type cold-forging machine), and the improvement and the cost cut of productivity by shortening of the cycle time can be aimed at now.

[0043] While the contour-forming process is further divided into the primary forming cycle and the secondary-forming process, setting the cylinder-like material W in the direction of an axial center in a primary forming cycle, setting an ellipse configuration or in the shape of an abbreviation gold coin and carrying out lump deformation Owner stage shaping of the part equivalent to the top face of middle Plastic solid W1 which is a process configuration while [the] having deformed, i.e., one side face of the cam piece 1, is carried out at a configuration including two flat surfaces 5a and 5b. It fabricates in the configuration which the thickness increases gradually toward the part which should serve as the cam crowning (nose section) 3 of the cam piece 1 so that it may mention later.

[0044] Moreover, at a secondary-forming process, while it sets in order to carry out flattening of middle Plastic solid W1 by which owner stage shaping was carried out further in a primary forming cycle, and preparing a profile configuration in the configuration of the cam piece 1, printing pressure shaping of the cavity 4 is carried out at the part which should serve as the shaft hole 2. Although the cavity 4 in this process does not necessarily need to be fabricated, when lessening the field which should serve as a scrap in the case of pierced earring processing which distributes material meat and is later mentioned from an early stage as much as possible, it acts effectively.

[0045] When a contour-forming process is finished with this secondary-forming process, Under-fill Q may occur still more in some middle Plastic solids W1. So, at the correction process following a contour-forming process, it sets in the thickness direction, preparing further the profile configuration of middle Plastic solid W1, and it sets right so that Under-fill Q may be lost.

[0046] The part in which the cavity 4 was previously formed among middle Plastic solids W1 is pierced by the shear method of construction by making this into a prepared hole, and the shaft hole 2 is fabricated at a pierced earring process.

Furthermore, in a bore cover-printing process, ironing is performed with press fit of a mandrel about the shaft hole 2, and the inner skin of the shaft hole 2 is finished in the shape of toothing with the gestalt like a hole spline.

[0047] Although drawing 1 shows the cylinder-like thing as a material W, it is more desirable to use the so-called material Wc of the profile configuration of the cam piece 1 which is a product as shown, for example in drawing 2 , and the variant configuration which makes an analog. The material Wc of such a variant configuration can be fabricated by the continuous casting process as shown in drawing 3 . That is, casting shaping is carried out as a cylindrical material Wn of a variant configuration by drawing out with through the die 13 by which forced cooling was carried out with the cooling system 12 according the molten metal in a holding furnace 11 to water etc., and drawing out with equipment 14. In addition, this kind of technique is well-known at JP,5-104209,A etc.

[0048] Although it is also possible to cut from a cylindrical material in a predetermined dimension at a last process beforehand, and to supply this to the contour-forming process shown in drawing 1 irrespective of whether Material W (or Wc) is a cylinder-like thing or it is the thing of a variant configuration, it is desirable on process compaction and a middle inventory dissolution to supply a cylindrical material to a multi-process forging press machine directly, to cut at the initial process, and to supply to the contour-forming process which is a back process as it is. Moreover, what was drawn out and fabricated is made into a variant configuration in roll forming etc., casting as a method of fabricating the material Wc of the above-mentioned variant configuration in the shape of the round bar besides the approach of fabricating directly by the above-mentioned continuous casting process, and you may make it supply this to a cutting process.

[0049] since there be little ingredient migration in the major axis direction of the cam piece 1 at the time of forging and it end when a material Wc be beforehand make into a variant configuration as mentioned above , it be large , the cam piece 1 of cam lifts with a large difference , i.e. , amount , of a major axis and a minor axis , or the cam piece 1 the cam crowning 3 sharpened in a peace much more can be fabricate easily , and also when lessen the routing counter within a contour forming process , it act effectively . And when deformation until it becomes the configuration of the cam piece 1 needed from a material configuration decreases, the load of metal mold is mitigated and it becomes advantageous also on the reinforcement. Therefore, it is also possible to be able to make deformation in a primary forming cycle small much more, to mix the primary forming cycle and secondary-forming process of drawing 1 substantially with

the magnitude of the cam piece 1 etc., and to form a contour-forming process into 1 process.

[0050] Although the material Wc of the variant configuration shown in (A) of drawing 2 is defined by the radius of curvature R0 as the circular section of the part equivalent to the cam crowning (nose section) 3, the aperture angle theta 0 of the cam crowning 3, and the ratios D0/d0 of a major axis D0 and a minor axis d0 It is desirable to become the same as the ratios D1/d1 of those radius of curvatures R0 and the radius of curvature R1 of the cam crowning 3 of the cam piece 1 which is a final product configuration, respectively as shown in this drawing (B) of the value of D0/d0 besides the value of the aperture angle theta 0, the aperture angle theta 1 and a major axis D1, and a minor axis d1. However, when all conditions must have been fulfilled from the constraint on shaping of a shaping limitation, a capacity rating limitation, etc., it is made to make as priority the configuration of Material Wc, and the configuration of the cam piece 1 which is a product in agreement in order of the radius of curvature R0 of (1) cam crowning, the aperture angle theta 0 of (2) cam crowning, and the ratios D0/d0 of the (3) major axis D and a minor axis d. In addition, priority here corresponds with the ranking of the difficulty of configuration precision **** in the case of fabricating the cam piece 1 from the cylinder-like material W in the contour-forming process of drawing 1 .

[0051] Here, when the tangent cam of the configuration connected with two tangents with which both share the base circle of the cam piece 1 and the radii section of the cam crowning 3 smaller than this as the aperture angle theta of the above-mentioned cam crowning 3 as shown in drawing 2 is assumed, the include angle which two tangents make is said.

[0052] In the middle of the material W which finished primary shaping at the contour-forming process of drawing 1 , the process configuration W1, i.e., a middle Plastic solid As shown also in drawing 4 So that the direction of partial 5a by the side of the cam crowning 3 may become high, though partial 5a, it, and partial 5b of the opposite side which are equivalent to the cam crowning 3 side among the fields equivalent to one side face of the cam piece 1 which is a product are parallel to the side face of another side The thickness dimension as middle Plastic solid W1 serves as a configuration increased gradually toward the cam crowning 3 side by being a configuration with a level difference between these two flat surfaces 5a and 5b. When this thought is applied to the material Wc of the variant configuration described previously, it means that both the cross sections in each same include-angle alpha** of middle Plastic solid W1 which is a process configuration in the middle of Material Wc

as shown in drawing 5 , and the product slack cam piece 1 are the same.

[0053] It is unsymmetrical and material volume is secured in the thickness direction as a configuration of the middle Plastic solid W1 to a product configuration like the above-mentioned cam piece 1 by which volume inclines toward the one direction, and the part equivalent to the cam crowning 3 is made brought near and filled with an ingredient, equalizing a thickness dimension gradually afterwards. The flow or plastic flow of an ingredient by the side of the cam crowning 3 it is easy to become inadequate [fullness of an ingredient] by carrying out like this in many cases [crowning] is promoted, and while shaping of the cam piece 1 with which the cam crowning 3 sharpened much more is attained, the percent defective by under-fill etc. is improved sharply. Of course, by promoting a flow of an ingredient, the load which shaping takes will be mitigated and it can contribute also to the reinforcement of metal mold.

[0054] Moreover, if middle Plastic solid W1 which makes Materials W or Wc a former configuration as mentioned above serves as a configuration with a level difference including two flat surfaces 5a and 5b, the posture of middle Plastic solid W1 in the secondary-forming process following a primary forming cycle will be stable, and it will act effective in especially generating prevention of under-fill. For example, if middle Plastic solid W1 serves as a configuration with the level difference which includes two parallel fields 5a and 5b mutually as shown in drawing 6 Deform plastically correctly in the shape of a cross-section rectangle in the case of secondary forming set by the dice 6 and punch 7, and after that under-fill etc. prevents [generating], that of ****** is received advantageously. When it does not have the level difference which includes two parallel fields 5a and 5b mutually, it is in the middle of shaping, and as shown in drawing 7 , middle Plastic solid W1 falls over, a phenomenon arises, it deforms cross-section trapezoidal shape or in the shape of a rhombus, and generating of Under-fill Q etc. is obliged.

[0055] In the secondary-forming process of the contour-forming process shown in drawing 1 , the cavity 4 is fabricated for making it function as a prepared hole which serves as an origin of punching in the case of pierced earring processing at a back process, while bringing near an ingredient by the part which should serve as the cam crowning 3 positively. On the other hand, if coincidence shaping of the cavity 4 is carried out, generating of the unevenness of thickness will become unescapable with the ingredient upheaval by the periphery. Then, the correction process following a contour-forming process is performed in order to correct the unevenness of this thickness.

[0056] In a pierced earring process, after piercing and fabricating the shaft hole 2, the configuration like a hole spline is made to the shaft hole 2 by inserting the mandrel of the shape of a pin of the same cross-section configuration as a shaft etc. in the shaft hole 2 at a bore cover-printing process, and performing ironing. This obtains the cam piece 1 as a product as shown in drawing 8 .

[0057] In this way, as shown in drawing 1 , carburization hardening is performed to the cam piece 1 which finished plastic working, and required surface hardness is secured. That is, since a surface carbon content is insufficient of Material W or the Wc itself unlike high-carbon steel as stated previously, carburization processing at a back process is needed. As the cam piece 1 to which carburization hardening was performed is shown in drawing 9 , compared with the hardening article of high-carbon steel, the hardness distribution differs and becomes what has a low internal degree of hardness.

[0058] Finally, although the cam piece 1 will be combined with the shaft used as the other party, in case a mandrel is inserted in the shaft and it carries out diameter expansion (expansion) association, it receives an impact load, the input attaches it, and it causes a crack of the cam piece 1 at the time. In this case, it acts advantageously that the internal hardness of the cam piece 1 is low as mentioned above, and it becomes possible for shock resistance to improve and to prevent generating of the crack of the cam piece 1 at the time of diameter expansion. If the ingredient which raised impact strength by adding boron (B) beforehand as Material W or Wc especially is used, it will become more advantageous on the crack prevention at the time of the above-mentioned diameter expansion processing.

[0059] The drawing below drawing 10 shows the concrete processing procedure of the multi-process forging press machine under the above-mentioned manufacture approach.

[0060] Drawing 10 shows the primary forming cycle of the above-mentioned contour-forming processes, and after inserting the material Wc of a variant configuration as shown at drawing 11 in the dice 22 which has knock out pin 21, it sets it by punch 23. In the middle of Material Wc, by this the process configuration W1, i.e., a middle Plastic solid It becomes a configuration with a level difference so that the direction of field 5a by the side of the cam crowning 3 may become high, though field 5a, it, and field 5b of the opposite side which are equivalent to the cam crowning 3 side among the fields equivalent to one side face of the cam piece 1 which is a product are parallel to the side face of another side as shown also in drawing 12 . Forging shaping is carried out at the configuration which the thickness dimension as middle Plastic

solid W1 increases gradually toward the cam crowning 3 side as a result.

[0061] Drawing 13 shows the secondary-forming process of the contour-forming processes, after inserting middle Plastic solid W1 shown in drawing 12 into the dice 25 which has a lower punch 24, it sets it by the upper punch 26, and it carries out printing pressure shaping of the cavities 4a and 4b to both sides while carrying out flattening so that a level difference, two comrades (field 5a and 5b), may be lost. Middle Plastic solid W1 as shown in drawing 14 by this is acquired. In addition, since Cavities 4a and 4b function as a prepared hole of the shaft hole 2 like the hole spline configuration described previously, in order to bring close to the configuration, they have been made into the polygonal configuration here.

[0062] Drawing 15 carries out pressurization constraint of middle Plastic solid W1 which shows the correction process following a contour-forming process, and was shown in drawing 14 by the lower punch 28 and the upper punch 29 within the dice 27, and corrects a configuration. Middle Plastic solid W1 with which configuration precision was raised more as the result as shown in drawing 16 is acquired.

[0063] Drawing 17 shows the pierced earring process, and pierces and fabricates the shaft hole 2 to middle Plastic solid W1 shown in drawing 16 based on shearing of a piercing punch 33 and an upper punch 32 within a dice 30. In addition, the tip of a piercing punch 33 is formed in the axial spline configuration, and Scrap S is generated by the center section of middle Plastic solid W1 being pierced as a shaft hole 2, as shown in drawing 18 .

[0064] To middle Plastic solid W1 which shows the bore ironing process and was shown in drawing 18 within the dice 34, drawing 19 presses the counterpunch 37 of the axial spline configuration for bore ironing fit in the shaft hole 2, and finishes the shaft hole 2 in the shape of [of a hole spline configuration] normal form. As the result, the cam piece 1 as shown in drawing 20 will be obtained. In addition, the counterpunch 47 which replaced with the counterpunch 37 shown in drawing 19 , and was shown in drawing 21 can also be used.

[0065] The drawing below drawing 22 shows the example when the so-called multistage type cold-forging machine (cold former) of a horizontal **** type is made to perform shaping at each process which is drawing showing the gestalt of operation of the 2nd of this invention, and was shown in (B) of drawing 1 , and (C).

[0066] The multistage type cold-forging machine 50 has the primary forming cycle S2 of a contour-forming process and the secondary-forming process S3, and correction process S4, the pierced earring process S5, the bore cover-printing process S6 and the work-piece discharge process S7 as well as the cutting process S1 which cuts the

material Wc of a variant configuration as shown in drawing 2 from a coil strip by making a bolster 51 into a subject, as shown in drawing 22 besides drawing 1 . In addition, it is considered beforehand that it combines with the completeness as cam piece 1 increasing, and the outer-diameter dimension becomes large gradually, passing through some processes of (B) of drawing 1 , and (C).

[0067] While the space of drawing 22 , the cutter 52 which cuts the coil strip (it mentions later about the coil strip itself) supplied from a rectangular cross for the material Wc of a variant configuration like drawing 2 , and the gripper 53 which grasps the material Wc after cutting are formed in the cutting process S1, the dice 54 is formed in the primary forming cycle S2, the secondary-forming process S3, correction process S4, the pierced earring process S5, and the bore cover-printing process S6 at each. Moreover, the work-piece discharge punch 55 which appears frequently from the space and the rectangular direction of drawing 22 is formed in the last work-piece discharge process S7. and -- since this multistage type cold-forging machine 50 can be understood to be what leveled drawing 10 and the direction of an opposite axis of the dice and punch in 13, 15, 17, and 19 -- a bolster 51 -- receiving -- the approach from a horizontal direction -- alienation -- the punch which counters each dice is formed in the ram besides the illustration which operates.

[0068] The transport device 56 for carrying out sequential conveyance of middle Plastic solid W1 fabricated at each processes S2-S6 at degree process is formed above the bolster 51. This transport device 56 an air cylinder or a servo motor to the slider 58 which carries out level round trip migration based on the actuation of the drive unit 57 made into a subject It is a thing equipped with a total of five grippers 59A-59E for grasping middle Plastic solid W1 or the cam piece 1. While each grippers 59A-59E are located so that it may not interfere in the front-face side of the corresponding dice 54 with this, the reciprocation stroke of a slider 58 and spacing of grippers are set up so that it may become equal to each process S2 - the pitch between S7. In addition, the multistage type forging machine equipped with this kind of transport device is well-known at JP,11-47877,A etc.

[0069] And if the condition of drawing 22 is made into a conveyance standby condition, middle Plastic solid W1 which finished shaping at each processes S2-S6 will be grasped by each grippers 59A-59E which are in a conveyance standby condition so that it may mention later. Middle Plastic solid W1 currently grasped by each grippers 59A-59E because each grippers 59A-59E move to degree process all at once based on the forward movement of a slider 58 after that is conveyed to degree process. Each grippers 59A-59E will return to the location again shown in a conveyance

standby condition, i.e., drawing 22 , based on double-acting actuation of a slider 58, after standing by at degree process with a slider 58 temporarily and completing shaping until shaping at degree the process is completed.

[0070] In addition, the duty which conveys this to the primary forming cycle S2 after grasping the material Wc of the variant configuration cut from the coil strip by the cutter 52 of the cutting process S1 so that the gripper 53 in the cutting process S1 may also carry out synchronous actuation with each above-mentioned grippers 59A-59E and may mention later is carried out.

[0071] Each gripper 53, and 59A-59E are equipped with the piece 60 of a pawl of the pair in which rocking closing motion is free as shown in drawing 23, and they grasp middle Plastic solid W1 or the cam piece 1 to each piece 60 of a pawl by the retention span determined with the spring constant of flat spring 62 by connecting the gripper body 61 and each piece 60 of a pawl by flat spring 62. When the punch only with the bigger specified quantity than middle Plastic solid W1 which the piece 60 of a pawl is grasping has advanced into the opening edge of the grasping side in each piece 60 of a pawl so that comparatively big C beveling (a sign 63 shows a chamfer) may be performed and it may mention later, it permits extruding middle Plastic solid W1, extending the piece 60 of a pawl with the punch.

[0072] Here, in connection with sequential processing progressing to the bore cover-printing process S6 from the primary forming cycle S2, it is beforehand set up so that the profile configuration as middle Plastic solid W1 may become little by little large each time, therefore each grippers 59A-59E have given beforehand the grasping cost which can respond to the difference in the above-mentioned profile configuration.

[0073] Therefore, if the detail is explained according to the structure of such a multistage type cold-forging machine 50, referring to drawing 24 , for example by making the primary forming cycle S2 into the example of representation, as shown in this drawing (A) Synchronizing with the forward movement of the previous slider 58, the material W of the variant configuration after cutting processing is conveyed to the front location of the dice 54 of the primary forming cycle S2, after having been grasped by the gripper 553, and it is positioned in the location. That is, a dice 54 side carves (impression), and it is positioned so that 64 and the profile of the material W currently grasped by the gripper 53 may be in agreement. And if punch 65 of the primary forming cycle S2 carries out advance actuation, Material W will be pushed in in the carve lump 64, and while punch 65 extends the piece 60 of a pawl of a gripper 53, as shown in this drawing (B), primary shaping will be given with the same gestalt as drawing 10 .

[0074] After primary shaping is completed, as shown in this drawing (C), punch 65 retreats first, and all the grippers 59A-59E (Grippers 59A-59E all are not grasping Material Wc or middle Plastic solid W1) containing the gripper 53 which was subsequently standing by by the primary forming cycle S2 till then return to the original location all at once by double-acting actuation of a slider 58. By this, gripper 59A will be located in the primary forming cycle S2 instead of a gripper 53. while a knockout punch (knock out pin) 66 carries out advance actuation as shown in this drawing (D) in this condition, and extruding middle Plastic solid W1 in the carve lump 64 -- in addition -- and the piece 60 of a pawl of gripper 59A is extended with that middle Plastic solid W1, and gripper 59A is made to grasp middle Plastic solid W1 after primary shaping Shortly after gripper 59A grasps middle Plastic solid W1, a knockout punch 66 returns to the original location.

[0075] When this condition is the same as the condition of this drawing (A) except that gripper 59A was changed, therefore the slider 58 of a transport device 56 performs the next conveyance actuation, middle Plastic solid W1 after the primary shaping termination currently grasped by that gripper 59A will be conveyed to the following secondary-forming process S3.

[0076] Such a series of actuation is fundamentally the same also in each processes S3-S6 other than primary forming cycle S2, and actuation of all the processes S1-S7 synchronizes, and it is performed in parallel. However, in the work-piece discharge process S7, as shown in drawing 25 , synchronizing with the knockout punch 66 of each processes S2-S6 carrying out advance actuation, work-piece discharge punch 67 carries out advance actuation, and only actuation which extrudes the cam piece 1 (refer to drawing 1) which finished bore ironing from gripper 59E is performed. And the cam piece released from gripper 58E is collected as a product.

[0077] The carve lump 64 of the dice 54 in each processes S2-S6 here It is set up so that the so-called cam top equivalent section which will manage shaping of the cam crowning 3 as shown in drawing 26 may serve as facing down. The conveyance posture of the material Wc by the gripper 53 and transport device 56 which were described previously, or middle Plastic solid W1 is also beforehand set up for that cam crowning 3 side so that it may become facing down, in order to double the posture of middle Plastic solid W1 with coincidence to the posture of this lump [carve] 64.

[0078] Therefore, if it explains taking the case of the primary forming cycle S2 shown in drawing 24 In case this is stuffed into the carve lump 64, releasing the material Wc of a variant configuration from a gripper 53 by extrusion actuation by punch 65 Only few amounts beta carry out self-weight fall of the material Wc at the moment of being

released from a gripper 53, as shown also in drawing 26 and 27. Since the cam crowning 3 side is downward, Material Wc and the cam top equivalent section of the lump [carve] 64 will agree immediately with the profile by the side of the cam crowning 3, and the so-called self ROKETO function or an automatic alignment function will be demonstrated.

[0079] In more detail, as shown also in drawing 27 , only the specified quantity beta carries out self-weight fall at the moment of the material Wc of the variant configuration currently grasped by the gripper 53 having been extruded by punch 65, and being released from the retention span. Primary shaping will be given by the cam crowning 3 and cam top equivalent section by the side of the carve lump 64 agreeing immediately, and being pushed into the pars-basilaris-ossis-occipitalis side of the lump [carve] 64 while it has been in the condition in which ingredient allocation inclined toward the cam crowning 3 side substantially.

[0080] Therefore, ingredient allocation inclines toward the cam crowning 3 side from the quite early stage rather than the welding pressure of punch 65 acts on Material Wc. Would give priority to the cam crowning 3 side beforehand, and the ingredient (material meat) will be full. The cam crowning 3 side it is supposed that an ingredient cannot be easily full of the crowning harder [which is acute /-like / with last thing] in many cases can be made fully filled with an ingredient, especially, generating of the thickness deviation by the side of the cam crowning 3 or under-fill is prevented, and it can also be contributed to the forging progression in quality now that it is cold forging.

[0081] conversely, when saying and the sense of the lump [carve] 64 in each dice 54 is set up so that the cam crowning 3 side may serve as facing up as shown in drawing 28 The moment Material Wc carried out self-weight fall, Material Wc falls over within the carve lump 64, a phenomenon occurs, especially since ingredient fullness is insufficient, it becomes easy to generate the thickness deviation and under-fill by the side of the cam crowning 3, and such fault can be effectively canceled with the gestalt of the above-mentioned implementation.

[0082] In addition, although drawing 26 and the behavior of 27 were explained taking the case of drawing 1 and the primary forming cycle S2 shown in 24, the behavior is fundamentally the same also about each other processes S3-S6. Moreover, even when W is used for the material W of the shape of a cylinder as replaced with the material Wc of a variant configuration and shown in drawing 1 , it cannot be overemphasized that the ingredient allocation which thought the cam crowning 3 side as important similarly so that clearly from drawing 29 can be given.

[0083] Furthermore, when it sees about the relation between the carve lump 64 of the

dice 54 in the primary forming cycle S2 described previously, and the carve lump 64 of the secondary-forming process S3 which is a back process as shown in drawing 30 for example, Since it is premised on carrying out the parallel displacement of middle Plastic solid W1 horizontally [process / S3 / which is a back process / secondary-forming], and conveying it from the primary forming cycle S2 which is a last process, The center-of-gravity location G of the lump [carve] 64 of both sides is made mutually in agreement, and as shown in drawing 26 and 27, in case it stuffs middle Plastic solid W1 into the carve lump 64 of the secondary-forming process S3 accumulating, middle Plastic solid W1 will carry out self-weight fall only of the specified quantity beta.

[0084] Then, when only the specified quantity a (=beta) makes the center-of-gravity location G of the lump [carve] 64 of the secondary-forming process S3 which is a back process offset beforehand up to the center-of-gravity location G of the lump [carve] 64 of the primary forming cycle S2 which is a last process as shown in drawing 30 , the above-mentioned self-weight deposit beta will be offset. That is, the height location of the section [cam crowning 3 and cam top equivalent section by the side of the carve lump 64] will already have corresponded in the phase where middle Plastic solid W1 conveyed from the primary forming cycle S2 as shown in drawing 32 is grasped by gripper 59A. Without being accompanied by the previous self-weight fall only for the amount beta of offset, as an interrelation of the carve lump 64 and middle Plastic solid W1, ingredient allocation can be made into priority or the condition of having made it inclining at the cam crowning 3 side, and the relative-position arrangement precision of middle Plastic solid W1 and the lump [carve] 64 improves much more.

[0085] As shown in drawing 30 , even if it is the case where the above amounts a of offset are not set up between the carve lump 64 by the primary forming cycle S2 which is a last process, and the secondary-forming process S3 which is a back process, and 64 comrades here If it sets up so that the cam crowning 3 side may serve as facing down as a conveyance posture of middle Plastic solid W1 If it is made to drop middle Plastic solid W1 positively by the above-mentioned amount a of offset, and the EQC in the conveyance process of middle Plastic solid W1 from the primary forming cycle S2 to the secondary-forming process S3 (offset), the same effectiveness as the above will be acquired.

[0086] A setup of the amount a of offset of the lump [carve] 64 between these before process and a back process (=beta) or the amount a of offset in a conveyance process is similarly set up in other process S4-S6 by which two processes will adjoin

mutually.

[0087] Next, the desirable gestalt of the coil strip of the variant configuration which will be supplied to the multistage type cold-forging machine 50 of drawing 22 is explained.

[0088] The cylindrical material Wn fabricated by the continuous casting process, for example as shown in drawing 3 is made into a coil strip 70 by being rolled round by the predetermined drum by making the field of the opposite side into the inside with the cam crowning 3 side at a back process, as shown in drawing 33 , and this coil strip 70 is set to the uncoiler 71 arranged at the preceding paragraph of the multistage type cold-forging machine 50 as shown in drawing 34 . In addition, when the cam crowning 3 side is carried out inside, since the touch area is small, carrying out the cam crowning 3 side outside, and rolling round the cylindrical material Wn, as shown in drawing 33 has bad stability, and it is because there is a possibility of making the most important cam crowning 3 deforming on a function. And a coil strip 70 will be supplied to the multistage type cold-forging machine 50, after passing through a straightening machine 72, being rewound by the uncoiler 71, and it will be sent out one by one from the dice of the cutting process S1 of drawing 22 .

[0089] In this case, if it sets to an uncoiler 71 so that the rewinding starting position 73 of a coil strip 70 may turn up as shown in drawing 34 , in the leader of a coil strip 70, it will not be in agreement with the posture in which the cam crowning 3 side becomes facing up, and the posture 3, i.e., cam crowning, side made into an ideal becomes the multistage type forging which was described previously with facing down. Therefore, by the time it conveys the material Wn cut at the cutting process S1 to the primary forming cycle S2, it will be necessary to make the posture reversed, and it is not desirable.

[0090] Then, it can be made now in agreement with the posture in which the posture [in which the posture in the leader of a coil strip 70 is made into an ideal at multistage type forging] 3, i.e., cam crowning, side serves as facing down, by setting the coil strip 70 to an uncoiler 71, and carrying out it like this so that the rewinding starting position 73 of a coil strip 70 may turn up, as shown in drawing 35 .

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* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The explanatory view showing the outline configuration of the process as a gestalt of desirable implementation of the manufacture approach of the cam piece concerning this invention.
[Drawing 2] The explanatory view which compared the material and product configuration of a variant configuration.
[Drawing 3] The explanatory view showing the outline of the continuous casting process for obtaining a cylindrical material.
[Drawing 4] The configuration explanatory view of the middle Plastic solid which carried out owner stage shaping.
[Drawing 5] The explanatory view which compared with the product configuration the middle Plastic solid which is a process configuration the middle.
[Drawing 6] The explanatory view of a secondary-forming process using drawing 4 and the middle Plastic solid of 5.
[Drawing 7] The explanatory view of a secondary-forming process in case two parallel fields cannot be mutually found in a middle Plastic solid.
[Drawing 8] The explanatory view of the cam piece completed with the bore cover-printing process of drawing 1 .
[Drawing 9] The property Fig. showing hardness distribution of the cam piece after carburization hardening processing.
[Drawing 10] The important section expansion explanatory view showing the detail of a primary forming cycle among the contour-forming processes shown in drawing 1 .
[Drawing 11] The explanatory view of the material of the variant configuration used by the primary forming cycle of drawing 10 .
[Drawing 12] The explanatory view of the middle Plastic solid acquired by the primary forming cycle of drawing 10 .

[Drawing 13] The important section expansion explanatory view showing the detail of a secondary-forming process among the contour-forming processes shown in drawing 1 .

[Drawing 14] The explanatory view of the middle Plastic solid acquired at the secondary-forming process of drawing 13 .

[Drawing 15] The important section expansion explanatory view showing the detail of the correction process shown in drawing 1 .

[Drawing 16] The explanatory view of the middle Plastic solid acquired at the correction process of drawing 15 .

[Drawing 17] The important section expansion explanatory view showing the detail of the pierced earring process shown in drawing 1 .

[Drawing 18] The explanatory view of the middle Plastic solid acquired at the pierced earring process of drawing 17 .

[Drawing 19] The important section expansion explanatory view showing the detail of the bore cover-printing process shown in drawing 1 .

[Drawing 20] The explanatory view of the cam piece completed with the bore cover-printing process of drawing 19 .

[Drawing 21] The explanatory view showing other examples of the tool used at the bore cover-printing process of drawing 19 .

[Drawing 22] The transverse-plane explanatory view showing the outline configuration of the multistage type cold-forging machine of a horizontal **** type as a gestalt of operation of the 2nd of this invention.

[Drawing 23] The important section enlarged drawing of the gripper used with the multistage type cold-forging machine of drawing 22 .

[Drawing 24] The cross-section explanatory view showing the material between the dices and grippers in the primary forming cycle of drawing 22 , or the delivery condition of a middle Plastic solid.

[Drawing 25] The cross-section explanatory view showing actuation at the work-piece discharge process of drawing 22 .

[Drawing 26] The explanatory view showing the relation between the material in a primary forming cycle, and the carve lump by the side of a dice.

[Drawing 27] The actuation explanatory view in the vertical section of drawing 26 .

[Drawing 28] The explanatory view at the time of making the material of drawing 26 , and the sense of a lump [carve] into the reverse sense.

[Drawing 29] The explanatory view showing the relation between the material at the time of replacing with the material of the variant configuration of drawing 26 , and

using a cylindrical material, and the carve lump by the side of a dice.

[Drawing 30] The explanatory view showing the relative-position relation of a lump [carve] of a primary forming cycle and a secondary-forming process to drawing 22 .

[Drawing 31] The explanatory view at the time of drawing 30 carving and setting up the amount of offset of the specified quantity in the vertical direction as relative-position relation of lumps.

[Drawing 32] The actuation explanatory view in the vertical section of drawing 31 .

[Drawing 33] The important section enlarged section explanatory view of the coil strip before being cut as a material of a variant configuration.

[Drawing 34] The explanatory view showing the general set condition of the coil strip to an uncoiler.

[Drawing 35] The explanatory view showing the set condition over the uncoiler of the coil strip adopted with the gestalt of the 2nd operation.

[Description of Notations]

1 -- Cam piece as a product

2 -- Shaft hole

3 -- Cam crowning (nose section)

4 -- Cavity

4a, 4b -- Cavity

5a, 5b -- Flat surface

50 -- Multistage type cold-forging machine of a horizontal **** type

64 -- Carve lump

70 -- Coil strip

71 -- Uncoiler

73 -- Rewinding starting position

Q -- Under-fill

R0 -- Curvature of the cam crowning as the circular section

S1 -- Cutting process

S2 -- Primary forming cycle (contour-forming process)

S3 -- Secondary-forming process (contour-forming process)

S4 -- Correction process

S5 -- Pierced earring process

S6 -- Bore cover-printing process

S7 -- Work-piece discharge process

W -- Material

W1 -- Middle Plastic solid

Wc -- Material of a variant configuration

[Translation done.]

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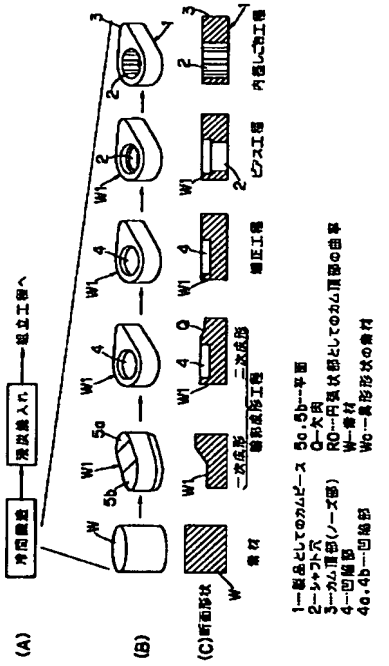
(54)【発明の名称】　組立式カムシャフト用カムピースの製造方法

(57)【要約】
【課題】　冷間鍛造を基本とした形状精度の優れたカムピースの製造方法を提供する。
【解決手段】　素材Ｗを据え込んでカムピース１の輪郭形状を鍛造成形する輪郭成形工程と、中間成形体Ｗ１の中央部にシャフト穴２を打ち抜き成形するピアス工程と、シャフト穴２の内周面を仕上げる内径しごき工程とを含んでいて、各工程での成形が冷間処理として行われる。輪郭成形工程の一次成形で得られる中間成形体Ｗ１は、カムピース１の一方の側面に相当する面のうちカム頂部３側の面５ａとそれと反対側の面５ｂとが他方の側面と平行でありながらカム頂部３側の面５ａの方が高くなるように段差を有した形状となっていて、中間成形体Ｗ１としての厚み寸法がカム頂部３側に向かって漸増する形状となっている。



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【特許請求の範囲】

【請求項１】　素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、

上記各工程での成形が冷間処理として行われるとともに、

上記輪郭成形工程での素材の途中工程形状として、カムピースの一方の側面に相当する面のうちカム頂部側の部分とそれと反対側の部分とが他方の側面と平行でありながらカム頂部側の部分の方が高くなるように段差を有した形状となっていることにより、素材としての厚み寸法がカム頂部側に向かって漸増する形状となっていることを特徴とする組立式カムシャフト用カムピースの製造方法。

【請求項２】　上記輪郭成形工程は少なくとも一次成形工程とそれに続く二次成形工程とに分かれていて、

一次成形後の中間成形体は、カムピースの一方の側面に相当する面のうちカム頂部側の部分とそれと反対側の部分とが他方の側面と平行でありながらカム頂部側の部分の方が高くなるように段差を有した形状となっていることにより、中間成形体としての厚み寸法がカム頂部側に向かって漸増する形状となっていることを特徴とする請求項１に記載の組立式カムシャフト用カムピースの製造方法。

【請求項３】　素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、

上記各工程での成形が冷間処理として行われるとともに、

上記輪郭成形工程に投入される素材には、少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の曲率の円弧状部が予め形成されていることを特徴とする組立式カムシャフト用カムピースの製造方法。

【請求項４】　上記輪郭成形工程に投入される素材には、少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の開き角が予め付与されていることを特徴とする請求項３に記載の組立式カムシャフト用カムピースの製造方法。

【請求項５】　上記輪郭成形工程に投入される素材はカムピースと相似形をなしていて、その素材の長径と短径との比率がカムピースと同じ比率に設定されていることを特徴とする請求項４に記載の組立式カムシャフト用カムピースの製造方法。

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【請求項６】　上記輪郭成形工程とピアス工程および内径しごき工程を含んでなる多工程鍛造プレス工法を基本工法とする請求項１～５のいずれかに記載の組立式カムシャフト用カムピースの製造方法。

【請求項７】　上記素材は低炭素鋼もしくは低炭素の合金鋼であり、輪郭成形工程とピアス工程および内径しごき工程とを含んでなる冷間処理後に浸炭処理を施すことを特徴とする請求項１～６のいずれかに記載の組立式カムシャフト用カムピースの製造方法。

【請求項８】　素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、

少なくとも上記各工程での成形が、カム頂部側を下向きにした状態でそれぞれ冷間処理として横打ち式の多段式鍛造機にて行われるようになっていることを特徴とする組立式カムシャフト用カムピースの製造方法。

【請求項９】　上記輪郭成形工程は少なくとも一次成形工程とそれに続く二次成形工程とが含まれていることを特徴とする請求項８に記載の組立式カムシャフト用カムピースの製造方法。

【請求項１０】　上記各工程での成形とともに、各工程間での中間成形体の搬送が同じくカム頂部側を下向きにした状態で行われるようになっていることを特徴とする請求項８または９に記載の組立式カムシャフト用カムピースの製造方法。

【請求項１１】　隣り合う二つの工程のうち前工程で成形された中間成形体の輪郭形状よりも後工程で成形された中間成形体の輪郭形状の方が大きくなるように設定されていて、

後工程のダイスの彫り込みに対して中間成形体を押し込み挿入する際に、予めカム頂部を彫り込み側のカム頂部相当部に合致させた上で押し込み挿入することを特徴とする請求項８～１０のいずれかに記載の組立式カムシャフト用カムピースの製造方法。

【請求項１２】　予めカム頂部を後工程側の彫り込みのカム頂部相当部に合致させた上で中間成形体を押し込み挿入する手段として、

前工程側の彫り込みの重心位置に対して後工程側の彫り込みの重心位置を所定量だけ予め上方側にオフセットさせてあることを特徴とする請求項１１に記載の組立式カムシャフト用カムピースの製造方法。

【請求項１３】　予めカム頂部を後工程側の彫り込みのカム頂部相当部に合致させた上で中間成形体を押し込み挿入する手段として、

前工程から後工程に中間成形体を搬送する過程でその中間成形体の重心位置を所定量だけ下方に移動させることを特徴とする請求項１１に記載の組立式カムシャフト用

カムピースの製造方法。

【請求項１４】　カムピースの形状と略相似形の断面形状をもつ異形形状で且つ長尺なコイル材を多段式鍛造機の初期工程に供給して、コイル材からの素材の切断までも多段式鍛造機にて行うようにした組立式カムシャフト用カムピースの製造方法であって、

カム頂部相当部を外側にして巻き取ったコイル材の巻き戻し開始位置が下側になるようにそのコイル材をアンコイラーにセットして、

そのコイル材を巻き戻しながら上記多段式鍛造機に供給することを特徴とする請求項８～１３のいずれかに記載の組立式カムシャフト用カムピースの製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、内燃機関の動弁系の主要素として機能することになる組立式カムシャフト用カムピースの製造方法に関し、特に別々に形成した中空状シャフトと鍛造品であるカムピースとをシャフトの拡径（拡管）処理により相互に一体化して組立式カムシャフトとするのに好適なカムピースの製造方法に関する。

【０００２】

【従来の技術と発明が解決しようとする課題】組立式カムシャフトのカムピース（カムロブ（ｃａｍ　ｌｏｂｅ）もしくはカムロッブとも称される）としては焼結品のほか鍛造品が用いられており、鍛造品のカムピースの場合には特に表面硬さを確保するために素材として例えばＳ７０Ｃ、Ｓ５５Ｃ相当の高炭素鋼を用い、鍛造後に焼入れ処理を施した上で使用される。そして、鍛造品のカムピースは、例えば特開平９－２７６９７６号公報および特開平９－２８００１３号公報に示されているように成形性に優れた熱間鍛造により成形されるのが一般的である。

【０００３】一方、組立式カムシャフトはカムピースとパイプ状のシャフトとの圧入強度および相互組み付け精度を両者の圧入代で保証するようにしているため、シャフトの外形寸法およびカムピースの内径寸法には高い精度が要求されることになるが、熱間鍛造にて成形された高炭素鋼の鍛造カムピースの場合には熱間鍛造時の酸化スケールの発生や熱収縮による寸法変化のために部品としての要求精度を十分に確保することができない。そのため、カムピースの内径寸法確保のためにブローチ加工に代表されるような切削加工もしくは冷間塑性加工等の仕上げ加工を別工程にて施す必要があり、工程数の増加および中間在庫の管理工数の増加によるコストアップが余儀なくされる。

【０００４】また、高炭素鋼の鍛造カムピースの場合、表面硬さを確保するために焼入れ処理を施す必要があるが、材質自体の特殊性として焼入れ時における焼き割れを皆無にすることは不可能であり、その焼き割れを原因

とする圧入組立時の破損や圧入力不足の発生を未然に防止するために焼き割れ発生の有無の検査や焼き割れ品の選別工程が必須となり、歩留まりの低下とともに工程数の増加によるコストアップが一層顕著となる。

【０００５】そこで、熱間鍛造に代わる冷間鍛造を基本としたカムピースの製造方法が特許第２７６７３２３号公報として提案されている。

【０００６】ところが、冷間鍛造は熱間鍛造に比べて鍛造成形性（素材肉の流動性）が低いために、欠肉等の欠陥が発生しやすいばかりでなく、素材から必要な製品形状まで塑性変形させる際に変形量を十分に小さくしないと型に対する成形荷重が大きくなり、型の摩耗が激しくなって型の早期寿命を招きやすい。

【０００７】特に、中実円筒状の素材を軸方向に据え込んで圧縮した場合には外周方向にほぼ均等な量だけ膨出するかたちとなるので、単純な円形状もしくはそれに近い形状に成形することは比較的容易ではあっても、円形のベースサークルとこれよりも著しく曲率半径の小さなカム頂部となるべき円弧部（ノーズ部）とを合成したようなカムピース形状に一気に且つ欠肉の発生のないように成形することは難しい。そのため、素材から製品形状まで微少量づつ塑性変形させて成形するべく加工工程数を多くする必要があり、鍛造設備が大型且つ高価なものとなるばかりでなく、加工時間も長くなって生産性の低下を招きやすい。

【０００８】本発明はこのような課題に着目してなされたものであり、冷間鍛造を前提としながらもより少ない工程数でしかも欠肉等の発生のない高精度なカムピースを製造できるようにした方法を提供するものである。

【０００９】

【課題を解決するための手段】請求項１に記載の発明は、素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、上記各工程での成形が冷間処理として行われるとともに、上記輪郭成形工程での素材の途中工程形状として、カムピースの一方の側面に相当する面のうちカム頂部側の部分とそれと反対側の部分とが他方の側面と平行でありながらカム頂部側の部分の方が高くなるように段差を有した形状となっていることにより、素材としての厚み寸法がカム頂部側に向かって漸増する形状となっていることを特徴とする。

【００１０】また、請求項２に記載の発明は、請求項１の記載をより具体化したものであり、上記輪郭成形工程は少なくとも一次成形工程とそれに続く二次成形工程とに分かれている。そして、一次成形後の中間成形体は、カムピースの一方の側面に相当する面のうちカム頂部側の部分とそれと反対側の部分とが他方の側面と平行であ

りながらカム頂部側の部分の方が高くなるように段差を有した形状となっていることにより、中間成形体としての厚み寸法がカム頂部側に向かって漸増する形状となっていることを特徴とする。

【００１１】この場合、素材としては例えば円柱状（中実円筒状）のものでもよいが、材料の塑性流動を一段と促進して欠肉等の欠陥を防止する上では、最終製品であるカムピースの形状と相似形の素材を用いることが望ましい。

【００１２】したがって、この請求項１，２に記載の発明では、大きく分けて輪郭成形工程とピアス工程および内径しごき工程を経ることによりシャフト穴を有するカムピースが成形されることになるが、輪郭成形工程における素材の途中工程形状であるところの一次成形後の中間成形体として、カム頂部側に向かって肉厚寸法が漸増する形状となっていると、その後の鍛造成形もしくは一次成形に続く二次成形の段階でカムピースの長径方向での肉流れすなわち塑性流動が促進されるようになり、特にカム頂部側での欠肉発生防止の上で有効に作用するようになる。

【００１３】請求項３に記載の発明は、素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、上記各工程での成形が冷間処理として行われるとともに、上記輪郭成形工程に投入される素材には、少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の曲率の円弧状部が予め形成されていることを特徴とする。

【００１４】したがって、この請求項３に記載の発明では、上記と同様に少なくとも輪郭成形工程とピアス工程および内径しごき工程を経ることによりシャフト穴を有するカムピースが成形されることになるが、素材のうち少なくともカム頂部となるべき部分にそのカムピースの頂部と同等の曲率の円弧状部が予め形成されていると、冷間鍛造によるカムピースの輪郭の成形、特に長径と短径との差の大きなカムピースを成形する上で有利となる。

【００１５】請求項４に記載の発明は、請求項３の記載を前提として、輪郭成形工程に投入される素材には、少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の開き角が予め付与されていることを特徴とする。

【００１６】ここで、上記開き角とは、カムピースのベースサークルとこれよりも小さなカム頂部の円弧部とを両者が共有する二つの接線にてつなげた形状の接線カムを想定した場合に二つの接線同士のなす角度をいう。

【００１７】この場合、請求項５に記載のように、輪郭成形工程に投入される素材はカムピースと相似形をなしていて、その素材の長径と短径との比率がカムピースと同じ比率に設定されていることが望ましい。

【００１８】したがって、これらの請求項４，５に記載の発明では、素材のうち少なくともカム頂部に相当する部分もしくは素材全体が予め最終製品であるカムピースの形状と相似形に形成されていることにほかならず、冷間鍛造によるカムピースの輪郭の成形の一段と容易となる。

【００１９】ここで、上記請求項１～５に記載の発明においては、請求項６に記載のように、いずれの場合にも輪郭成形工程とピアス工程および内径しごき工程を含んでなる多工程鍛造プレス工法すなわち多段式冷間鍛造機による工法を基本工法とすることが生産性向上の上で好ましい。

【００２０】また、請求項７に記載のように、請求項１～６のいずれかの記載を前提とした上で、素材として低炭素鋼もしくは低炭素の合金鋼を用い、輪郭成形工程とピアス工程および内径しごき工程とを含んでなる冷間処理後に浸炭処理を施すことが冷間での成形性向上の上で望ましい。

【００２１】請求項８に記載の発明は、素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、少なくとも上記各工程での成形が、カム頂部側を下向きにした状態でそれぞれ冷間処理として横打ち式の多段式鍛造機にて行われるようになっていることを特徴とする。

【００２２】この場合、請求項９に記載のように、上記輪郭成形工程には少なくとも一次成形工程とそれに続く二次成形工程とが含まれていてもよい。

【００２３】また、請求項１０に記載のように、各工程での成形とともに、各工程間での中間成形体の搬送が同じくカム頂部側を下向きにした状態で行われるようになっていることがより望ましい。

【００２４】したがって、これらの請求項８～１０に記載の発明では、中間成形体を前工程から後工程に搬送してその後工程側の金型（ダイス）の彫り込み（インプレション（ｉｍｐｒｅｓｓｉｏｎ）ともいう）に挿入すれば、中間成形体のカム頂部とそれの成形を司る彫り込みのカム頂部相当部とがセルフロケート機能もしくは自動調芯機能を発揮し、早い時期から両者が合致して、彫り込み内での中間成形体のいわゆる転がり現象が防止されることになる。これは、彫り込みに対して中間成形体の位置がカム頂部側に偏っていて、材料（素材肉）ボリュームの配分がそのカム頂部側に偏っていることにほかならないから、カム頂部側へ優先して材料ボリュームが配分されてそのカム頂部側での材料充満が促進され、機能上最も重要なカム頂部側での偏肉や欠肉を防止する上で

きわめて有効に作用するようになる。

【００２５】請求項１１に記載の発明は、請求項８～１０のいずれかの記載の前提として、隣り合う二つの工程のうち前工程で成形された中間成形体の輪郭形状よりも後工程で成形された中間成形体の輪郭形状の方が大きくなるように設定されていて、後工程のダイスの彫り込みに対して中間成形体を押し込み挿入する際に、予めカム頂部を彫り込み側のカム頂部相当部に合致させた上で押し込み挿入することを特徴とする。

【００２６】より具体的には、請求項１２に記載のように、予めカム頂部を後工程側の彫り込みのカム頂部相当部に合致させた上で中間成形体を押し込み挿入する手段として、前工程側の彫り込みの重心位置に対して後工程側の彫り込みの重心位置を所定量だけ予め上方側にオフセットさせておくか、もしくは請求項１３に記載のように、予めカム頂部を後工程側の彫り込みのカム頂部相当部に合致させた上で中間成形体を押し込み挿入する手段として、前工程から後工程に中間成形体を搬送する過程でその中間成形体の重心位置を所定量だけ下方に移動させるものとする。

【００２７】したがって、これら請求項１１～１３に記載の発明では、後工程の彫り込みに対して前工程からの中間成形体を挿入する際に、その中間成形体のカム頂部と彫り込み側のカム頂部相当部が自律的に合致するようになる。

【００２８】請求項１４に記載の発明は、請求項８～１３のいずれかの記載を前提とした上で、カムピースの形状と略相似形の断面形状をもつ異形形状で且つ長尺なコイル材を多段式鍛造機の初期工程に供給して、コイル材からの素材の切断までも多段式鍛造機にて行うにあたり、カム頂部相当部を外側にして巻き取ったコイル材の巻き戻し開始位置が下側になるようにそのコイル材をアンコイラーにセットして、そのコイル材を巻き戻しながら上記多段式鍛造機に供給することを特徴とする。

【００２９】すなわち、カム頂部相当部を外側にして巻き取ったコイル材の巻き戻し開始位置が上側になるようにコイル材をアンコイラーにセットして、そのコイル材を巻き戻しながら上記多段式鍛造機に供給することを前提とした場合、そのコイル材から切断された素材の向きはカム頂部側が上向きとなり、先に述べたようなカム頂部側が下向きとなるような理想的な姿勢とは逆の姿勢とならざるを得ないことから、請求項１４に記載の発明ではコイル材の巻き戻し開始位置が下側になるように予め考慮したものである。

【００３０】したがって、この請求項１４に記載の発明では、多段式鍛造機に切断材ではなくコイル材を直接供給して、素材そのもの切断までも多段式鍛造機にて行うことを前提とした場合に、切断直後の素材の向きが各工程での成形姿勢と一致したものとなり、鍛造工程の高速化の上でより好ましいものとなる。

【００３１】

【発明の効果】請求項１，２に記載の発明によれば、少なくとも輪郭成形工程とピアス工程および内径しごき工程とを含んでなる製造方法を前提として、輪郭成形工程における素材の途中工程形状であるところの一次成形後の中間成形体の形状として、カム頂部側に向かって肉厚寸法が漸増する形状となっていることから、カムピースの長径方向の肉流れが促進されるとともに、カム頂部側での素材肉の流速が相対的に大きくなってそのカム頂部側に速やかに充満することから、曲率半径の小さなカム頂部を速やかに且つ欠肉等の発生を伴うことなく容易に成形できる効果がある。また、カム頂部側まで素材肉を充満させるのに必要な成形荷重が軽減されて、金型の負荷の低減と併せてその長寿命化を達成できるようになる。

【００３２】請求項３に記載の発明によれば、輪郭成形工程に投入される素材には少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の曲率の円弧状部が予め形成されていることにより、特に長径と短径との差の大きなカムピースすなわちカムリフト量の大きなカムピースを冷間鍛造成形する際の輪郭形状の成形が容易となり、特に曲率半径の小さなカム頂部までも少ない工程数で容易に成形できる効果があるほか、上記と同様に金型の負荷の低減と併せてその長寿命化を達成できる利点もある。

【００３３】請求項４に記載の発明によれば、輪郭成形工程に投入される素材には少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の開き角が予め付与されていることにより、請求項３に記載の発明と同様の効果に加えて、カムピースの輪郭形状の成形が一層容易となり、さらなる工程数の削減と金型の長寿命化を達成できるようになるほか、特に請求項５に記載のように、素材がカムピースと相似形をなしていてその素材の長径と短径との比率がカムピースと同じ比率に設定されていると上記の効果が一段と顕著となる。

【００３４】請求項６に記載の発明によれば、請求項１～５のいずれの記載においても輪郭成形工程とピアス工程および内径しごき工程を含んでなる多工程鍛造プレス工法を基本工法としているため、必要最小限の工程数で所期の目的を達成することができるとともに連続成形が可能となり、工程数の削減と中間在庫の解消によるコストダウンならびに生産性の向上を図ることが可能となる。

【００３５】請求項７に記載の発明によれば、素材として冷間での成形性に優れた低炭素鋼もしくは低炭素の合金鋼を用いているため、冷間鍛造により素材から一気にカムピース形状に成形することが可能となり、カムピースの輪郭形状の冷間成形と内径形状の冷間成形を連続した工程で行うことができるようになって、工程数の削減と工程間在庫の解消によるコストダウンが可能となる。

【００３６】その上、冷間鍛造処理後に浸炭焼入れ処理を施して必要な表面硬さを確保するようにしているため、浸炭焼入れが施されたカムピースは高炭素鋼の焼入れ品と比べてその硬さ分布が異なり、内部硬度は低いものとなる。そして、カムピースは相手側となるシャフトにマンドレルを挿入して拡径結合する際に衝撃荷重を受けることになるが、上記のようにカムピースの内部硬さが低いことが有利に作用し、結果として耐衝撃性が向上して拡径時のカムピースの割れの発生を防止することが可能となる。

【００３７】請求項８，９に記載の発明によれば、上記各工程での成形がカム頂部側を下向きにした状態でそれぞれ冷間処理として多段式鍛造機にて行われるようになっていて、さらに請求項１０に記載の発明によれば、各工程間での中間成形体の搬送もカム頂部側を下向きにした状態で行われるようになっていることから、前工程から搬送されてきた中間成形体を後工程の彫り込みに挿入さえすれば、中間成形体のカム頂部とそれの成形を司る彫り込みのカム頂部相当部とが直ちに合致することになる。その結果、彫り込み内での中間成形体のいわゆる転がり現象を防止できることはもちろんのこと、彫り込みに対して中間成形体の位置がカム頂部側に偏っていて、実質的に材料配分が早い時期からカム頂部側に偏っていることにほかならないから、カム頂部側での材料充満が一段と促進されて、機能上最も重要なカム頂部側での偏肉や欠肉を確実に防止して、鍛造品質の向上に大きく貢献できるようになる。

【００３８】請求項１１に記載の発明によれば、後工程のダイスの彫り込みに対して中間成形体を押し込み挿入する際に、予めカム頂部を彫り込み側のカム頂部相当部に合致させた上で押し込み挿入するようにしたものであり、また請求項１２，１３に記載の発明によれば、その具体的手段として、前工程側の彫り込みの重心位置に対して後工程側の彫り込みの重心位置を所定量だけ予め上方側にオフセットさせておくか、もしくは前工程から後工程に中間成形体を搬送する過程でその中間成形体の重心位置を所定量だけ下方に移動させるようにしたものであるから、その中間成形体のカム頂部と彫り込み側のカム頂部相当部が自律的に合致するようになり、カム頂部側での材料充満効果が一段と促進されて、カム頂部側での偏肉や欠肉をより確実に防止できる利点がある。

【００３９】請求項１４に記載の発明によれば、カムピースの形状と略相似形の断面形状をもつ異形形状で且つ長尺なコイル材を多段式鍛造機に直接供給するにあたり、その切断後の素材の向きが上記カム頂部を下向きとした姿勢と一致するように予め考慮したものであるから、カム頂部側への材料充満がより一層促進されて、カム頂部側での偏肉や欠肉を防止しつつその形状精度が一層安定化するほか、素材として切断材を使用した場合と比べて鍛造工程数の削減と製造コストの低減が図れるようになる。

【００４０】

【発明の実施の形態】図１～９は本発明に係るカムピースの製造方法のより好ましい実施の形態を示している。

【００４１】図１の（Ａ）に示すように、冷間鍛造、浸炭焼き入れおよび組立工程を経て組み立てられることになる組立式カムシャフトについて、本実施の形態ではそのカムピース１の素材Ｗとして低炭素鋼もしくは低炭素の合金鋼（例えば、炭素Ｃの含有量が０．２％のＳＣｒ４２０Ｈ材）を用いることを前提とする。低炭素の材料は冷間での成形性が良いため、冷間鍛造により素材Ｗから一気にカムピース形状に成形することが可能となる。その結果、後述するようにカムピース１の輪郭形状を成形するための冷間成形と内径形状を成形するための冷間成形を連続の工程で行うことができるようになり、工程数の削減と工程間在庫の解消によるコストダウンが可能となる。

【００４２】冷間鍛造の工程はさらに図１の（Ｂ），（Ｃ）のように細分化されており、中実円筒状（円柱状）の素材Ｗをもってカムピース１の形状に成形する輪郭成形工程と、カムピース１の厚み寸法を整える矯正工程と、カムピース１の中央部に形成されるシャフト穴２の打ち抜き加工を行うピアス工程と、シャフト穴２の内周面について例えば穴スプライン形状の如き異形形状に仕上げ成形する内径しごき工程とが含まれている。これだけの工程数であれば輪郭成形工程から内径しごき工程までの全ての工程を高速の多工程鍛造プレス機（多段式冷間鍛造機）にて連続成形することが可能となり、サイクルタイムの短縮化による生産性の向上とコストダウンが図れるようになる。

【００４３】輪郭成形工程は、さらに一次成形工程と二次成形工程とに分かれており、一次成形工程では円柱状の素材Ｗをその軸心方向に据え込んで長円形状もしくは略小判状に据え込み変形させるとともに、その変形した途中工程形状であるところの中間成形体Ｗ１の上面すなわちカムピース１の一方の側面に相当する部分を二つの平面５ａ，５ｂを含む形状に有段成形して、後述するようにカムピース１のカム頂部（ノーズ部）３となるべき部分に向かってその肉厚が漸増する形状に成形する。

【００４４】また、二次成形工程では、一次成形工程にて有段成形された中間成形体Ｗ１をさらに偏平化させるべく据え込んで輪郭形状をカムピース１の形状に整えるとともに、シャフト穴２となるべき部分に凹陥部４を印圧成形する。この工程での凹陥部４の成形は必ずしも必要なものではないが、素材肉の分配を早い時期から行って後述するピアス加工の際にスクラップとなるべき領域を可及的に少なくする上で有効に作用する。

【００４５】この二次成形工程をもって輪郭成形工程を終えた場合に中間成形体Ｗ１の一部にはなおも欠肉Ｑが発生する可能性がある。そこで、輪郭成形工程に続く矯

正工程では中間成形体Ｗ１の輪郭形状をさらに整えながら厚み方向に据え込んで、欠肉Ｑがなくなるように矯正する。

【００４６】ピアス工程では、中間成形体Ｗ１のうち先に凹陥部４が形成された部分を、これを下穴としてせん断工法にて打ち抜いてシャフト穴２を成形する。さらに、内径しごき工程ではシャフト穴２についてマンドレルの圧入をもってしごき加工を施し、シャフト穴２の内周面を穴スプラインの如き形態で凹凸形状に仕上げる。

【００４７】図１では素材Ｗとして円柱状のものを示しているが、例えば図２に示すように製品であるカムピース１の輪郭形状と相似形をなすいわゆる異形形状の素材Ｗｃを用いることがより望ましい。このような異形形状の素材Ｗｃは例えば図３に示すような連続鋳造法によって成形することが可能である。すなわち、保持炉１１内の溶湯を水等による冷却装置１２にて強制冷却されたダイ１３を通しながら引き抜き装置１４にて引き抜くことで異形形状の棒状素材Ｗｎとして鋳造成形される。なお、この種の技術は例えば特開平５－１０４２０９号公報等で公知である。

【００４８】素材Ｗ（またはＷｃ）は円柱状のものであるか異形形状のものであるかにかかわらず予め前工程にて棒状素材から所定寸法に切断し、これを図１に示した輪郭成形工程に投入することも可能であるが、棒状素材を直接多工程鍛造プレス機に供給してその初期工程にて切断し、そのまま後工程である輪郭成形工程に投入するのが工程短縮および中間在庫解消の上で望ましい。また、上記異形形状の素材Ｗｃの成形法としては、上記連続鋳造法によって直接成形する方法のほか、丸棒状に鋳造しながら引き抜き成形したものをロール成形等にて異形形状にし、これを切断工程に投入するようにしてもよい。

【００４９】上記のように素材Ｗｃを予め異形形状とした場合には、鍛造時におけるカムピース１の長径方向への材料移動が少なくて済むため、長径と短径との差が大きいカムピース１すなわちカムリフト量が大きいかもしくはカム頂部３が一段と尖ったカムピース１の成形を容易に行えるほか、輪郭成形工程内での工程数を少なくする上でも有効に作用する。しかも、素材形状から必要とするカムピース１の形状となるまでの変形量が少なくなることによって金型の負荷が軽減されて、その長寿命化の上でも有利となる。したがって、一次成形工程での変形量を一段と小さくすることができ、カムピース１の大きさ等によっては実質的に図１の一次成形工程と二次成形工程とを一緒にして輪郭成形工程を一工程化することも可能である。

【００５０】図２の（Ａ）に示した異形形状の素材Ｗｃはカム頂部（ノーズ部）３に相当する部分の円弧状部としての曲率半径Ｒ０、カム頂部３の開き角θ０、および長径Ｄ０と短径ｄ０との比Ｄ０／ｄ０により定義される

が、それらの曲率半径Ｒ０および開き角θ０の値のほかＤ０／ｄ０の値のそれぞれが、同図（Ｂ）に示すように最終製品形状であるカムピース１のカム頂部３の曲率半径Ｒ１、開き角θ１、および長径Ｄ１と短径ｄ１との比Ｄ１／ｄ１と同じになるのが望ましい。ただし、成形限界や設備能力限界等の成形上の制約から全ての条件を満たし得ない場合には、（１）カム頂部の曲率半径Ｒ０、（２）カム頂部の開き角θ０、（３）長径Ｄと短径ｄとの比Ｄ０／ｄ０の順に優先順位として、素材Ｗｃの形状と製品であるカムピース１の形状とを一致させるようにする。なお、ここでの優先順位は、図１の輪郭成形工程において円柱状の素材Ｗからカムピース１を成形する場合の形状精度出しの難しさの順位と対応している。

【００５１】ここで、上記カム頂部３の開き角θとは、図２に示すようにカムピース１のベースサークルとこれよりも小さなカム頂部３の円弧部とを両者が共有する二つの接線にてつなげた形状の接線カムを想定した場合に二つの接線同士のなす角度をいう。

【００５２】図１の輪郭成形工程にて一次成形を終えた素材Ｗの途中工程形状すなわち中間成形体Ｗ１は、図４にも示すように、製品であるカムピース１の一方の側面に相当する面のうちカム頂部３側に相当する部分５ａとそれと反対側の部分５ｂとが他方の側面と平行でありながらカム頂部３側の部分５ａの方が高くなるようにそれら二つの平面５ａ，５ｂの間に段差を有した形状となっていることにより、中間成形体Ｗ１としての厚み寸法がカム頂部３側に向かって漸増する形状となっている。この思想を先に述べた異形形状の素材Ｗｃに適用した場合、図５に示すように素材Ｗｃの途中工程形状である中間成形体Ｗ１と製品たるカムピース１のそれぞれの同一角度α°での断面積が共に同じであることを意味している。

【００５３】上記カムピース１のような非対称で且つ一方向にボリュームが偏っている製品形状に対し、その中間成形体Ｗ１の形状として厚み方向で素材ボリュームを確保し、後から厚み寸法を徐々に均一化しながらカム頂部３に相当する部分に材料を寄せて充満させる。こうすることにより、材料の充満がとかく不十分となりやすいカム頂部３側への材料の流れもしくは塑性流動を促進して、一段とカム頂部３の尖ったカムピース１の成形が可能となるとともに、欠肉等による不良率が大幅に改善される。もちろん、材料の流動が促進されることによって成形に要する荷重が軽減されて、金型の長寿命化にも寄与できることになる。

【００５４】また、上記のように素材ＷまたはＷｃを元形状とする中間成形体Ｗ１が二つの平面５ａ，５ｂを含む段差を有した形状となっていると、一次成形工程に続く二次成形工程での中間成形体Ｗ１の姿勢が安定化し、特に欠肉の発生防止に有効に作用する。例えば、図６に示すように、中間成形体Ｗ１が互いに平行な二つの面５

ａ，５ｂを含む段差を有した形状となっていると、ダイス６とパンチ７とで据え込む二次成形の際に断面方形状に正しく塑性変形して欠肉等の発生防止の上で有利にはたらくのに対して、互いに平行な二つの面５ａ，５ｂを含む段差を有していない場合には、図７に示すように成形途中で中間成形体Ｗ１の転び現象が生じて断面台形状もしくは菱形状に変形してしまい、欠肉Ｑ等の発生が余儀なくされる。

【００５５】図１に示した輪郭成形工程の二次成形工程において凹陥部４を成形しているのは、カム頂部３となるべき部分に積極的に材料を寄せるとともに、後工程でのピアス加工の際に穴あけの起点となる下穴として機能させるためである。その一方で、凹陥部４を同時成形すると、その周辺部での材料隆起に伴い厚みの不均一さの発生が不可避となる。そこで、輪郭成形工程に続く矯正工程はこの厚みの不均一さを矯正するために行われる。

【００５６】ピアス工程において、シャフト穴２を打ち抜き成形した後に、内径しごき工程にてシャフトと同一断面形状のピン状のマンドレル等をシャフト穴２に挿入してしごき加工を施すことにより、シャフト穴２を穴スブラインのごとき形状に仕上げる。これにより、図８に示すような製品としてのカムピース１を得る。

【００５７】こうして塑性加工を終えたカムピース１に図１に示したように浸炭焼入れを施し、必要な表面硬さを確保する。すなわち、先に述べたように素材ＷまたはＷｃ自体が高炭素鋼と異なり表面の炭素量が不足しているので、後工程での浸炭処理が必要となる。浸炭焼入れが施されたカムピース１は、図９に示すように高炭素鋼の焼入れ品と比べてその硬さ分布が異なり、内部硬度は低いものとなる。

【００５８】カムピース１は最終的には相手側となるシャフトと組み合わされることになるが、そのシャフトにマンドレルを挿入して拡径（拡管）結合する際に衝撃荷重を受け、その入力が組み付け時のカムピース１の割れの原因となる。この際に、上記のようにカムピース１の内部硬さが低いことが有利に作用し、耐衝撃性が向上して拡径時のカムピース１の割れの発生を防止することが可能となる。特に、素材Ｗもしくはこれに予めホウ素（Ｂ）を添加することにより衝撃強度を向上させた材料を用いると、上記の拡径処理時の割れ防止の上で一段と有利となる。

【００５９】図１０以下の図面は上記の製造方法のもとでの多工程鍛造プレス機の具体的加工手順を示している。

【００６０】図１０は上記輪郭成形工程のうちの一次成形工程を示しており、ノックアウトピン２１を有するダイス２２の中に図１１に示すような異形形状の素材Ｗｃを挿入した上でパンチ２３により据え込む。これにより、素材Ｗｃの途中工程形状すなわち中間成形体Ｗ１は、図１２にも示すように製品であるカムピース１の一方の側面に相当する面のうちカム頂部３側に相当する面５ａとそれと反対側の面５ｂとが他方の側面と平行でありながらカム頂部３側の面５ａの方が高くなるように段差を有した形状となり、結果として中間成形体Ｗ１としての厚み寸法がカム頂部３側に向かって漸増する形状に鍛造成形される。

【００６１】図１３は輪郭成形工程のうちの二次成形工程を示しており、ロアパンチ２４を有するダイス２５の中に図１２に示した中間成形体Ｗ１を挿入した上でアッパーパンチ２６により据え込み、二つの面５ａ，５ｂ同士の段差をなくすように平坦化するとともに、両面に凹陥部４ａ，４ｂを印圧成形する。これによって図１４に示すような中間成形体Ｗ１を得る。なお、凹陥部４ａ，４ｂは先に述べた穴スブライン形状のごときシャフト穴２の下穴として機能することから、ここではその形状に近付けるために多角形の形状にしてある。

【００６２】図１５は輪郭成形工程に続く矯正工程を示しており、ダイス２７内にてロアパンチ２８とアッパーパンチ２９とで図１４に示した中間成形体Ｗ１を加圧拘束して形状の矯正を行う。その結果として、図１６に示すようにより形状精度が高められた中間成形体Ｗ１を得る。

【００６３】図１７はピアス工程を示しており、ダイス３０内にて図１６に示した中間成形体Ｗ１に対し、ピアスパンチ３３とアッパーパンチ３２とのせん断作用に基づきシャフト穴２を打ち抜き成形する。なお、ピアスパンチ３３の先端は軸スブライン形状に形成されており、図１８に示すように中間成形体Ｗ１の中央部がシャフト穴２として打ち抜かれることでスクラップＳが発生する。

【００６４】図１９は内径しごき加工工程を示しており、ダイス３４内にて図１８に示した中間成形体Ｗ１に対し、内径しごき加工用の軸スブライン形状のカウンターパンチ３７をシャフト穴２に圧入して、そのシャフト穴２を穴スブライン形状の正規形状に仕上げる。その結果として、図２０に示すようなカムピース１が得られることになる。なお、図１９に示したカウンターパンチ３７に代えて図２１に示したカウンターパンチ４７を用いることもできる。

【００６５】図２２以下の図面は本発明の第２の実施の形態を示す図であり、図１の（Ｂ），（Ｃ）に示した各工程での成形をいわゆる横打ち式の多段式冷間鍛造機（コールドフォーマー）にて行うようにした場合の例を示している。

【００６６】多段式冷間鍛造機５０は、図１のほか図２２に示すように、ボルスタ５１を主体として、コイル材から図２に示すような異形形状の素材Ｗｃを切断する切断工程Ｓ１と、同じく輪郭成形工程の一次成形工程Ｓ２および二次成形工程Ｓ３と、矯正工程Ｓ４、ピアス工程Ｓ５および内径しごき工程Ｓ６、およびワーク排出工程

Ｓ７とを有している。なお、図１の（Ｂ），（Ｃ）の幾つかの工程を経ながらカムピース１としての完成度が高まるのに併せてその外径寸法が徐々に大きくなるように予め考慮されている。

【００６７】切断工程Ｓ１には、図２２の紙面と直交方向から供給されるコイル材（コイル材そのものについては後述する）を図２のような異形形状の素材Ｗｃに切断するカッター５２と切断後の素材Ｗｃを把持するグリッパ５３が設けられている一方、一次成形工程Ｓ２、二次成形工程Ｓ３、矯正工程Ｓ４、ピアス工程Ｓ５および内径しごき工程Ｓ６にはそれぞれにダイス５４が設けられている。また、最終のワーク排出工程Ｓ７には図２２の紙面と直交方向から出没するワーク排出パンチ５５が設けられている。そして、この多段式冷間鍛造機５０は図１０，１３，１５，１７，１９におけるダイスとパンチとの対向軸線方向を水平にしたものと理解することができるから、ボルスタ５１に対して水平方向から接近離間動作する図示外のラムには各ダイスに対向するパンチが設けられている。

【００６８】ボルスタ５１の上方には、各工程Ｓ２～Ｓ６で成形された中間成形体Ｗ１を次工程に順次搬送するための搬送装置５６が設けられている。この搬送装置５６は、エアシリンダあるいはサーボモータ等を主体とする駆動ユニット５７の作動に基づいて水平往復移動するスライダ５８に、中間成形体Ｗ１もしくはカムピース１を把持するための合計５個のグリッパ５９Ａ～５９Ｅを装着したもので、各グリッパ５９Ａ～５９Ｅは対応するダイス５４の前面側にこれと干渉しないように位置しているとともに、スライダ５８の往復動ストロークおよびグリッパ同士の間隔は各工程Ｓ２～Ｓ７間ピッチと等しくなるように設定してある。なお、この種の搬送装置を備えた多段式鍛造機は例えば特開平１１－４７８７７号公報等で公知である。

【００６９】そして、図２２の状態を搬送待機状態とすると、後述するように搬送待機状態にある各グリッパ５９Ａ～５９Ｅには各工程Ｓ２～Ｓ６での成形を終えた中間成形体Ｗ１が把持され、その後にスライダ５８の往動動作に基づき各グリッパ５９Ａ～５９Ｅが一斉に次工程に移動することで各グリッパ５９Ａ～５９Ｅに把持されている中間成形体Ｗ１が次工程へと搬送される。各グリッパ５９Ａ～５９Ｅはその次工程での成形が終了するまでスライダ５８とともに次工程で一時待機し、成形が終了すると再びスライダ５８の復動動作に基づき搬送待機状態すなわち図２２に示す位置まで戻ることになる。

【００７０】なお、切断工程Ｓ１にあるグリッパ５３も上記の各グリッパ５９Ａ～５９Ｅと同期作動し、後述するように切断工程Ｓ１のカッター５２にてコイル材から切断された異形形状の素材Ｗｃを把持した上でこれを一次成形工程Ｓ２まで搬送する役目をする。

【００７１】各グリッパ５３および５９Ａ～５９Ｅは図２３に示すように揺動開閉自在な一対の爪片６０を備えていて、グリッパ本体６１と各爪片６０とが板ばね６２にて連結されていることにより、各爪片６０には板ばね６２のばね定数によって決定される把持力によって中間成形体Ｗ１もしくはカムピース１を把持するようになっている。各爪片６０における把持面の開口縁には比較的大きなＣ面取り（面取り部を符号６３で示す）が施されていて、後述するように爪片６０が把持している中間成形体Ｗ１よりも所定量だけ大きなパンチが進入してきたときには、そのパンチをもって爪片６０を押し広げながら中間成形体Ｗ１を押し出すのを許容するようになっている。

【００７２】ここで、一次成形工程Ｓ２から内径しごき工程Ｓ６へと順次加工が進むのに伴い、その都度中間成形体Ｗ１としての輪郭形状が少しずつ大きくなるように予め設定されており、したがって、各グリッパ５９Ａ～５９Ｅは上記の輪郭形状の違いに対応できるだけの把持代を予め持たせてある。

【００７３】したがって、このような多段式冷間鍛造機５０の構造によれば、例えば一次成形工程Ｓ２を代表例として図２４を参照しながらその詳細を説明すると、同図（Ａ）に示すように、先のスライダ５８の往動動作に同期して切断加工後の異形形状の素材Ｗがグリッパ５５３に把持された状態で一次成形工程Ｓ２のダイス５４の前面位置まで搬送されて、その位置に位置決めされる。すなわち、ダイス５４側の彫り込み（インプレッション）６４とグリッパ５３に把持されている素材Ｗの輪郭とが一致するように位置決めされる。そして、その一次成形工程Ｓ２のパンチ６５が前進動作すると、パンチ６５はグリッパ５３の爪片６０を押し広げながら素材Ｗを彫り込み６４内に押し込んで、同図（Ｂ）に示すように図１０と同様の形態で一次成形を施すことになる。

【００７４】一次成形が終了すると同図（Ｃ）に示すように最初にパンチ６５が後退し、次いでそれまで一次成形工程Ｓ２で待機していたグリッパ５３を含む全てのグリッパ５９Ａ～５９Ｅ（グリッパ５９Ａ～５９Ｅはいずれも素材Ｗｃもしくは中間成形体Ｗ１を把持していない）がスライダ５８の復動動作により一斉に元の位置に戻る。これにより、一次成形工程Ｓ２にはグリッパ５３に代わってグリッパ５９Ａが位置することになる。この状態で同図（Ｄ）に示すようにノックアウトパンチ（ノックアウトピン）６６が前進動作して、彫り込み６４内の中間成形体Ｗ１を押し出しながら、なお且つその中間成形体Ｗ１をもってグリッパ５９Ａの爪片６０を押し広げて一次成形後の中間成形体Ｗ１をグリッパ５９Ａに把持させる。グリッパ５９Ａが中間成形体Ｗ１を把持するとノックアウトパンチ６６は直ちに元の位置に戻る。

【００７５】この状態は、グリッパ５９Ａが入れ替わっている以外は同図（Ａ）の状態と同じであり、したがって、搬送装置５６のスライダ５８が次の搬送動作を行う

時にはそのグリッパ５９Ａに把持されている一次成形終了後の中間成形体Ｗ１は次の二次成形工程Ｓ３へと搬送されることになる。

【００７６】このような一連の動作は、一次成形工程Ｓ２以外の各工程Ｓ３～Ｓ６においても基本的に同様であって、全ての工程Ｓ１～Ｓ７の動作が同期して且つ並行して行われる。ただし、ワーク排出工程Ｓ７においては、図２５に示すように各工程Ｓ２～Ｓ６のノックアウトパンチ６６が前進動作するのと同期してワーク排出パンチ６７が前進動作して、内径しごき加工を終えたカムピース１（図１参照）をグリッパ５９Ｅから押し出す動作のみが行われる。そして、グリッパ５８Ｅから解放されたカムピースは製品として回収される。

【００７７】ここで、各工程Ｓ２～Ｓ６におけるダイス５４の彫り込み６４は、図２６に示すようにカム頂部３の成形を司ることになるいわゆるカム頂部相当部が下向きとなるように設定されており、同時にこの彫り込み６４の姿勢に対して中間成形体Ｗ１の姿勢を合わせるべく、先に述べたグリッパ５３および搬送装置５６による素材Ｗｃもしくは中間成形体Ｗ１の搬送姿勢もまたそのカム頂部３側が下向きとなるように予め設定されている。

【００７８】したがって、図２４に示した一次成形工程Ｓ２を例にとって説明すれば、パンチ６５による押し出し動作によってグリッパ５３から異形形状の素材Ｗｃを解放しつつこれを彫り込み６４に押し込む際に、図２６，２７にも示すようにグリッパ５３から解放された瞬間に素材Ｗｃはわずかな量βだけ自重落下し、カム頂部３側が下向きであるためにそのカム頂部３側のプロフィールをもって直ちに素材Ｗｃと彫り込み６４のカム頂部相当部とが合致して、いわゆるセルフロケート機能もしくは自動調芯機能が発揮されることになる。

【００７９】より詳しくは、図２７にも示すように、グリッパ５３に把持されていた異形形状の素材Ｗｃがパンチ６５によって押し出されてその把持力から解放された瞬間に所定量βだけ自重落下して、直ちにそのカム頂部３と彫り込み６４側のカム頂部相当部とが合致して、実質的にカム頂部３側に材料配分が偏った状態のままで彫り込み６４の底部側に押し込まれることで一次成形が施されることになる。

【００８０】そのため、素材Ｗｃにパンチ６５の加圧力が作用するよりもかなり早い時期からカム頂部３側に材料配分が偏っていて、そのカム頂部３側は予め優先して材料（素材肉）が充満していることになり、冷間鍛造であることもさることながら尖鋭状であるがためにとかく材料が充満しにくいとされるカム頂部３側に充分に材料を充満させることができ、特にそのカム頂部３側での偏肉や欠肉の発生を防止して鍛造品質の向上に寄与できるようになる。

【００８１】逆に言えば、図２８に示すように各ダイス５４における彫り込み６４の向きをカム頂部３側が上向きとなるように設定した場合には、素材Ｗｃが自重落下した瞬間に彫り込み６４内で素材Ｗｃの転び現象が発生し、材料充満不足のために特にカム頂部３側での偏肉や欠肉が発生しやすくなるのであって、上記実施の形態ではこのような不具合を効果的に解消できる。

【００８２】なお、図２６，２７の挙動は図１，２４に示した一次成形工程Ｓ２を例にとって説明したが、それ以外の各工程Ｓ３～Ｓ６についてもその挙動は基本的に同様である。また、異形形状の素材Ｗｃに代えて図１に示したような円柱状の素材ＷをＷを使用した場合でも、図２９から明らかなように同様にしてカム頂部３側を重視した材料配分を与えることができることは言うまでもない。

【００８３】さらに、図３０に示すように、例えば先に述べた一次成形工程Ｓ２におけるダイス５４の彫り込み６４と後工程である二次成形工程Ｓ３の彫り込み６４との関係についてみた場合、前工程である一次成形工程Ｓ２から後工程である二次成形工程Ｓ３へと中間成形体Ｗ１を水平に且つ平行移動させて搬送することを前提としているため、双方の彫り込み６４の重心位置Ｇは互いに一致させてあり、それがために図２６，２７に示したように中間成形体Ｗ１を二次成形工程Ｓ３の彫り込み６４に押し込む際に所定量βだけ中間成形体Ｗ１が自重落下することになる。

【００８４】そこで、図３０に示すように、後工程である二次成形工程Ｓ３の彫り込み６４の重心位置Ｇを前工程である一次成形工程Ｓ２の彫り込み６４の重心位置Ｇに対して所定量ａ（＝β）だけ上方に予めオフセットさせておくと、上記の自重落下量βが相殺されることになる。つまり、図３２に示すように一次成形工程Ｓ２から搬送されてきた中間成形体Ｗ１がグリッパ５９Ａに把持されている段階で既にそのカム頂部３と彫り込み６４側のカム頂部相当部とはその高さ位置が一致していることになり、先のオフセット量β分だけの自重落下を伴うことなしに彫り込み６４と中間成形体Ｗ１との相互関係として、カム頂部３側に材料配分を優先もしくは偏らせた状態とすることができ、中間成形体Ｗ１と彫り込み６４との相対位置決め精度が一段と向上する。

【００８５】ここで、図３０に示したように前工程である一次成形工程Ｓ２と後工程である二次成形工程Ｓ３との彫り込み６４，６４同士の間に上記のようなオフセット量ａを設定しない場合であっても、中間成形体Ｗ１の搬送姿勢としてそのカム頂部３側が下向きとなるように設定しておけば、一次成形工程Ｓ２から二次成形工程Ｓ３への中間成形体Ｗ１の搬送過程において上記オフセット量ａと同等分だけ中間成形体Ｗ１を積極的に下降（オフセット）させるようにすれば上記と同様の効果が得られることになる。

【００８６】これら前工程と後工程との間での彫り込み

６４のオフセット量ａ（＝β）の設定もしくは搬送過程でのオフセット量ａは、二つの工程が相互に隣接していることになる他の工程Ｓ４～Ｓ６においても同様に設定されている。

【００８７】次に、図２２の多段式冷間鍛造機５０に供給されることになる異形形状のコイル材の好ましい形態について説明する。

【００８８】図３に示すような例えば連続鋳造法により成形された棒状素材Ｗｎは、後工程にて図３３に示すようにカム頂部３側とは反対側の面を内側として所定のドラムに巻き取られることでコイル材７０とされ、このコイル材７０は図３４に示すように多段式冷間鍛造機５０の前段に配置されるアンコイラー７１にセットされる。なお、図３３に示すようにカム頂部３側を外側にして棒状素材Ｗｎを巻き取るのは、カム頂部３側を内側にすると接触面積が小さいために安定性が悪く、また機能上最も重要なカム頂部３を変形させてしまうおそれがあるためである。そして、コイル材７０はアンコイラー７１にて巻き戻されながら矯正機７２を経た上で多段式冷間鍛造機５０に供給されて、図２２の切断工程Ｓ１のダイスから順次送り出されることになる。

【００８９】この場合において、図３４に示すようにコイル材７０の巻き戻し開始位置７３が上側になるようにアンコイラー７１にセットすると、コイル材７０の始端部ではカム頂部３側が上向きとなってしまい、先に述べたような多段式鍛造に理想とされる姿勢すなわちカム頂部３側が下向きとなるような姿勢と一致しないことになる。したがって、切断工程Ｓ１で切断された素材Ｗｎを一次成形工程Ｓ２に搬送するまでの間にその姿勢を反転させる必要が生じることとなって好ましくない。

【００９０】そこで、図３５に示すようにコイル材７０の巻き戻し開始位置７３が上側になるようにそのコイル材７０をアンコイラー７１にセットするものとし、こうすることによりコイル材７０の始端部での姿勢が多段式鍛造に理想とされる姿勢すなわちカム頂部３側が下向きとなるような姿勢と一致させることができるようになる。

【図面の簡単な説明】

【図１】本発明に係るカムピースの製造方法の好ましい実施の形態としてその工程の概略構成を示す説明図。

【図２】異形形状の素材と製品形状とを比較した説明図。

【図３】棒状素材を得るための連続鋳造法の概略を示す説明図。

【図４】有段成形した中間成形体の構成説明図。

【図５】途中工程形状である中間成形体と製品形状とを比較した説明図。

【図６】図４，５の中間成形体を用いた二次成形工程の説明図。

【図７】中間成形体に互いに平行な二つの面がない場合の二次成形工程の説明図。

【図８】図１の内径しごき工程をもって完成したカムピースの説明図。

【図９】浸炭焼入れ処理後のカムピースの硬さ分布を示す特性図。

【図１０】図１に示す輪郭成形工程のうち一次成形工程の詳細を示す要部拡大説明図。

【図１１】図１０の一次成形工程で使用される異形形状の素材の説明図。

【図１２】図１０の一次成形工程で得られた中間成形体の説明図。

【図１３】図１に示す輪郭成形工程のうち二次成形工程の詳細を示す要部拡大説明図。

【図１４】図１３の二次成形工程で得られた中間成形体の説明図。

【図１５】図１に示す矯正工程の詳細を示す要部拡大説明図。

【図１６】図１５の矯正工程で得られた中間成形体の説明図。

【図１７】図１に示すピアス工程の詳細を示す要部拡大説明図。

【図１８】図１７のピアス工程で得られた中間成形体の説明図。

【図１９】図１に示す内径しごき工程の詳細を示す要部拡大説明図。

【図２０】図１９の内径しごき工程をもって完成したカムピースの説明図。

【図２１】図１９の内径しごき工程で使用される工具の他の例を示す説明図。

【図２２】本発明の第２の実施の形態として横打ち式の多段式冷間鍛造機の概略構成を示す正面説明図。

【図２３】図２２の多段式冷間鍛造機で使用されるグリッパの要部拡大図。

【図２４】図２２の一次成形工程におけるダイスとグリッパとの間での素材もしくは中間成形体の受け渡し状態を示す断面説明図。

【図２５】図２２のワーク排出工程での作動を示す断面説明図。

【図２６】一次成形工程における素材とダイス側の彫り込みとの関係を示す説明図。

【図２７】図２６の垂直断面での作動説明図。

【図２８】図２６の素材および彫り込みの向きを逆向きにした場合の説明図。

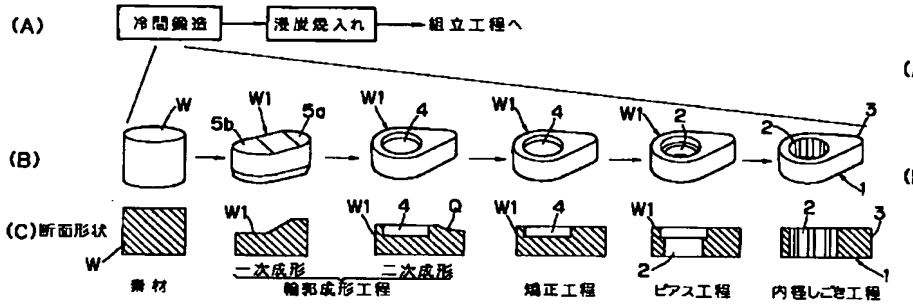
【図２９】図２６の異形形状の素材に代えて円柱状素材を用いた場合のその素材とダイス側の彫り込みとの関係を示す説明図。

【図３０】図２２における一次成形工程と二次成形工程の彫り込みの相対位置関係を示す説明図。

【図３１】図３０の彫り込み同士の相対位置関係として上下方向に所定量のオフセット量を設定した場合の説明

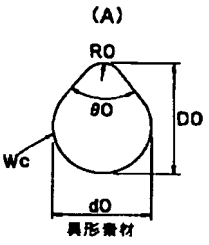
図。
【図３２】図３１の垂直断面での作動説明図。
【図３３】異形形状の素材として切断される前のコイル材の要部拡大断面説明図。
【図３４】アンコイラーに対するコイル材の一般的なセット状態を示す説明図。
【図３５】第２の実施の形態で採用されるコイル材のアンコイラーに対するセット状態を示す説明図。
【符号の説明】
１…製品としてのカムピース
２…シャフト穴
３…カム頂部（ノーズ部）
４…凹陥部
４ａ，４ｂ…凹陥部
５ａ，５ｂ…平面
５０…横打ち式の多段式冷間鍛造機
＊６４…彫り込み
７０…コイル材
７１…アンコイラー
７３…巻き戻し開始位置
Ｑ…欠肉
Ｒ０…円弧状部としてのカム頂部の曲率
Ｓ１…切断工程
Ｓ２…一次成形工程（輪郭成形工程）
Ｓ３…二次成形工程（輪郭成形工程）
Ｓ４…矯正工程
Ｓ５…ピアス工程
Ｓ６…内径しごき工程
Ｓ７…ワーク排出工程
Ｗ…素材
Ｗ１…中間成形体
＊　Ｗｃ…異形形状の素材

【図１】

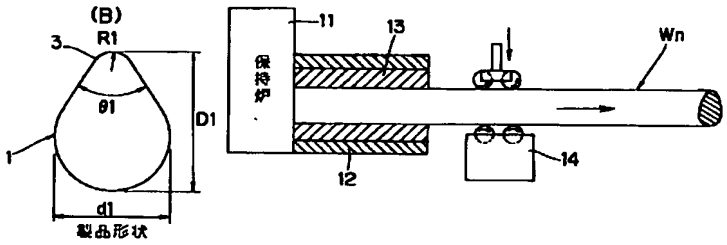


1…製品としてのカムピース　5a，5b…平面
2…シャフト穴　Q…欠肉
3…カム頂部(ノーズ部)　R0…円弧状部としてのカム頂部の曲率
4…凹陥部　W…素材
4a，4b…凹陥部　Wc…異形形状の素材

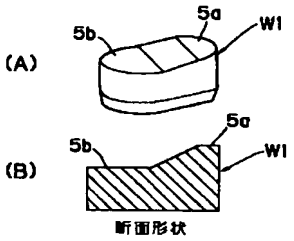
【図２】



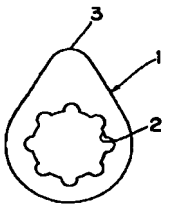
【図３】



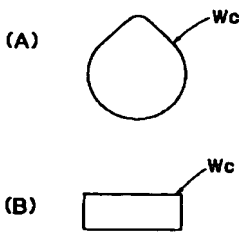
【図４】



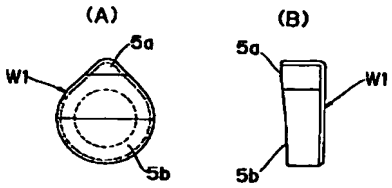
【図８】



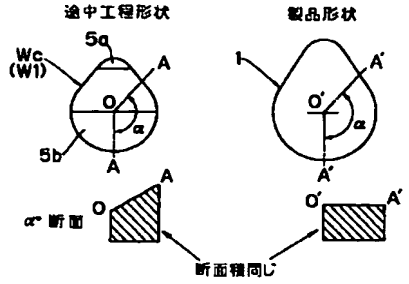
【図１１】



【図１２】



【図５】



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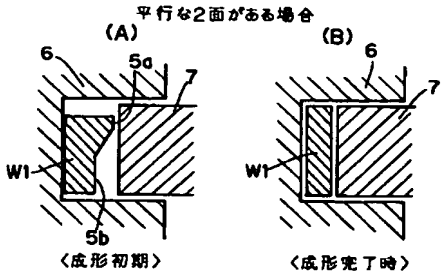

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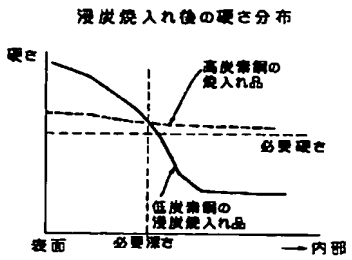

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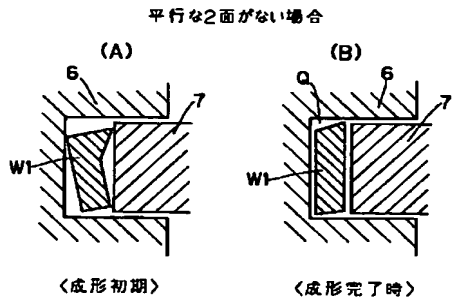

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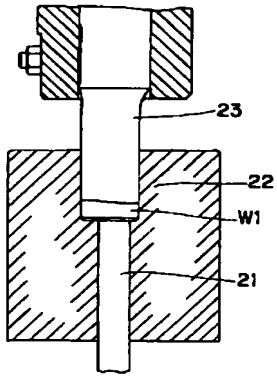

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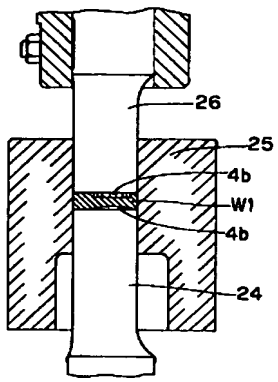

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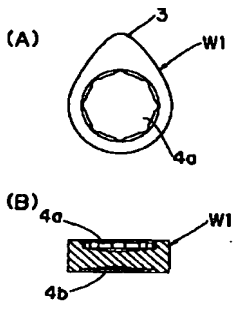

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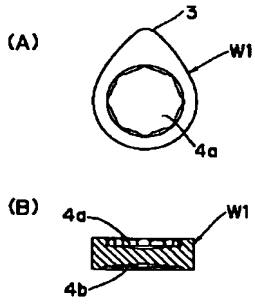

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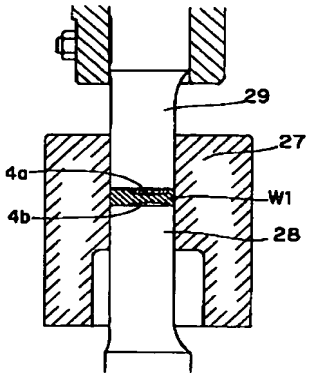

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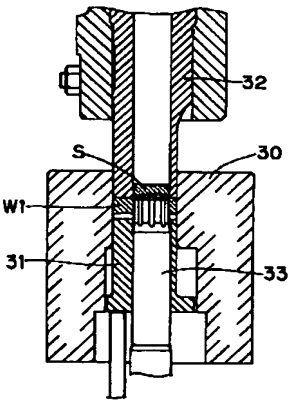

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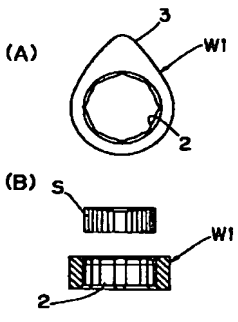

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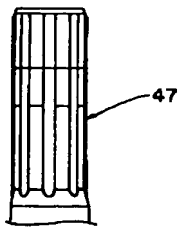

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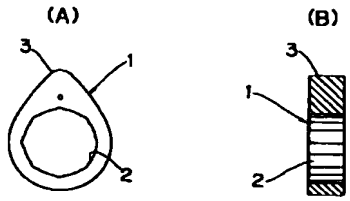

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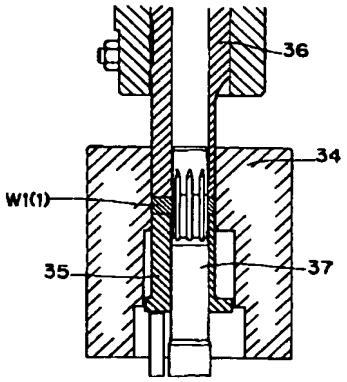

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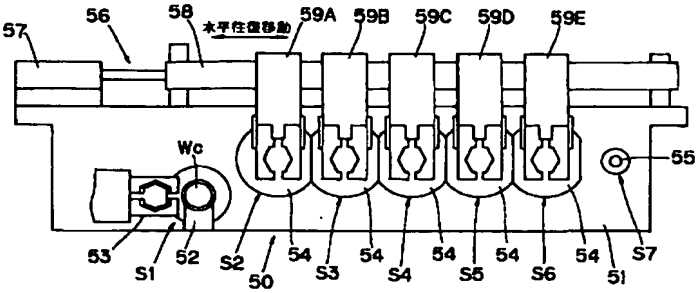

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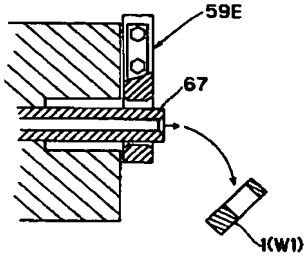

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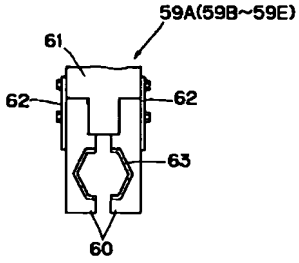

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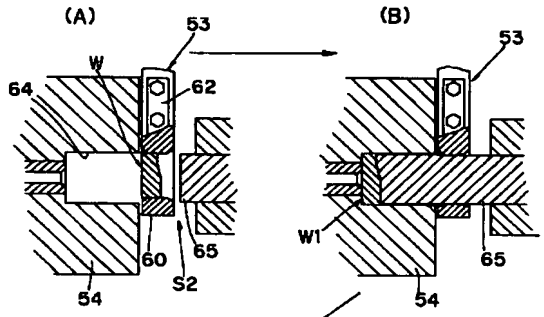

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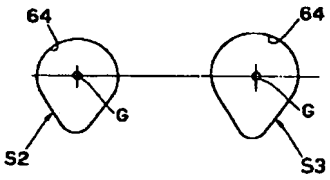

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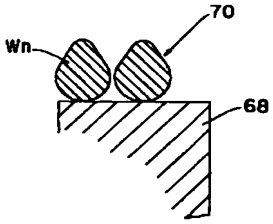

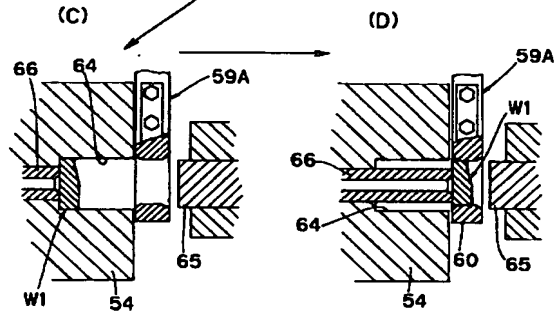

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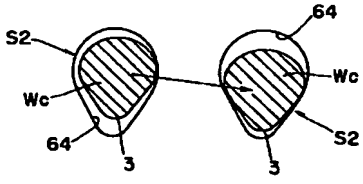

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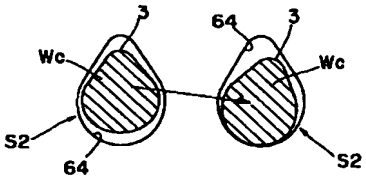

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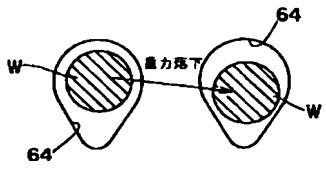

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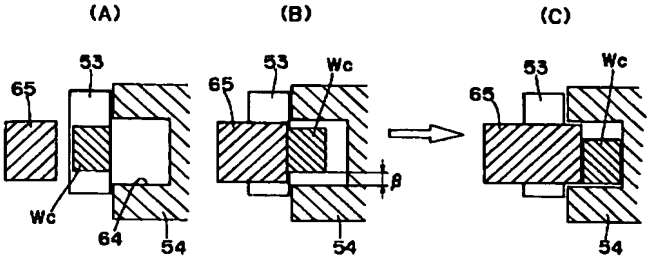

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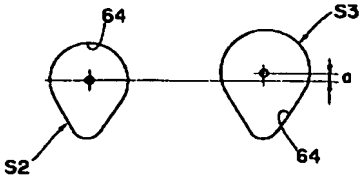

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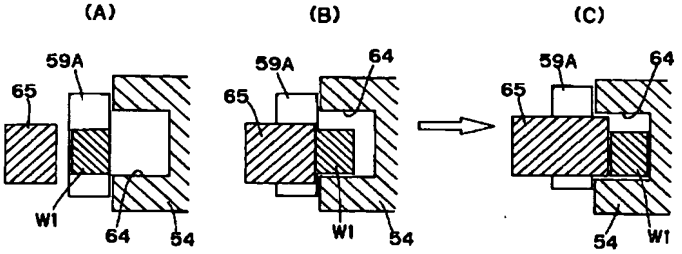

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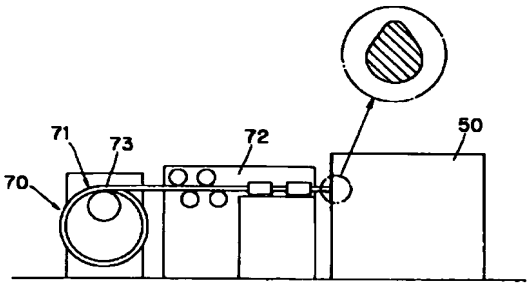

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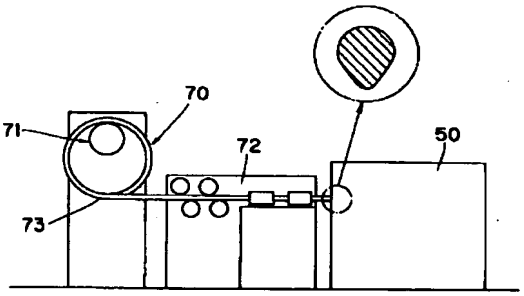

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(51)Int.Cl.'	識別記号	F I		テーマコード（参考）
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// Ｂ２１Ｋ 1/20		Ｂ２１Ｋ 1/20		

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